A COMPLEAT SYSTEM OF NAVIGATION;

In Two Parts.

I. ATKINSON's Epitome.

II. Navigation New Modell'd: Or, The Whole Art performed, without Tables or Instruments, by a New Method, never yet published: Illustrated with Practical Examples of keeping a Journal, and correcting by an Observation; with a New Way of finding the Variation, and Time of High-Water, at any known Port.

With Proper and Correct Tables, viz.

1. A Table of the Sun's Right Ascension. 2. A Table of the Right Ascension and Declination of the Principal fixed Stars. 3. A Table of the Sun's Declination, calculated for 20 years. 4. A Table of Latitudes and Longitudes of the Principal Harbours, Capes, and Islands, in the World. 5. A Table of Difference of Latitude and Departure, for the exact Working a Traverse. 6. A Table shewing the First Day of *March*, Epact, Dominical Letter; with a Perpetual Almanack. Likewise the Use and Description of the Quadrant, Cross-Staff, and Nocturnal. By H. Wilson.

To which is added, for the Help of young Seamen

The Draught of a Ship, with all her Rigging: Every Rope particularly described by its proper Name: and also a Dictionary, Explaining all the Terms used at Sea, in an Alphabetical Order.

DUBLIN:

Printed by BOULTER GRIERSON, Printer to the King's Most Excellent Majesty. M,DCCLXVII.

EPITOME
OF THE
ART of NAVIGATION;
OR, A
Short and easy Methodical Way to become a *Compleat Navigator.*

CONTAINING

Practical Geometry, Plain and Spherical, Superficial and Solid; with its USES in all Kinds of Mensuration.

Trigonometry, Plain and Spherical, both Geometrical, Instrumental, Logarithmetical, with its USES in NAVIGATION, *viz.*

In *Plain Mercator's* and *Great-Circle Sailing*, Geography, Astronomy, the Projection of the Sphere, &c.

The Description and Use of the *Plain-Chart*, *Mercator's-Chart*, both Globes, Hemispheres, and divers other Instruments.

A New Form of keeping a Sea-Reckoning, or Account of a Ship's Way.

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TO ALL LOVERS and LEARNERS OF NAVIGATION.

THE General Approbation of this Book, since its first Impression in 1686, hath obliged me not only to publish my Grateful Acknowledgment thereof; but also excited my diligent Search into, and exact Survey of every Part of its Structure, to find out the Defects; to know all its Deficiencies, which I have so far laboured in: That in this Eleventh Impression,

I have now rectified what was amiss, altered what was disorderly: explained what was dark or obscure; enlarged where it was scanty, added where it was wanting. And

These Ratifications, Alterations, Emendations, and Additions being in divers Places, I thought it needless to enumerate them; for they are obvious to a diligent Reader, that will but compare the Rules, Precepts, and Examples of this with the former Impressions, in the plain and easy Method they are placed in, which is thus;

1. You have Practical Geometry, explained by Definitions, Problems and Proportions. In this Chapter is taught the making the most useful Geometrical Figures, with the measuring all Superficies and Solids; also the Application thereof in Practical Measuring, Board, Glass, Plaistering, Painting, Paving, and Land: Timber and Stone; Gauging of Casks, and a Ship's Hold: all being illustrated with Rules, Proportions, and Examples, easy to the understanding, and not burthensome to the Memory; and so stated that they may be performed both by Arithmetick, and by the Line of Numbers on Gunter's Scale, in 37 Problems.

The

The first Chapter I advise the Learner to study well before he proceed, it being preparative to the next, as indeed they are all depending on one another, as Links in a Chain.

II. Plain Trigonometry is next, in which are many useful Notes, and Definitions, with the Axioms, and also the Cases depending on each Axiom, orderly set down in 8 Problems, containing 13 Cases.

And here I must advertise the Young Student that would work Trigonometry by the Logarithms, to consult Chapter 1. The explanation and general use of the Table of Logarithms, and Tables of Sines, Tangents, and Secants, toward the latter End of the Book; in Page 294.

III. Then follows Plain Trigonometry, applied in Problems of Sailing by the Plain Sea-Chart, commonly called Plain Sailing.

And that nothing be wanting I begin with the common Notes of the Julian Kalendar; shewing how to find the Prime, Epact, Dominical Letter, Easter-Day, the Moon's Age, Southing and Time of Full-Sea, or High-water. In 9 Problems.

Then proceeding to the description and use of the Plain Chart, in 5 Problems, before I come to the Cases of Plain Sailing, which I divide into 3 Parts.

1. In a Right-angle Triangle relating to a single Course; in which are 6 Cases, commonly called the 6 Cases of Plain Sailing.

2. In a Right-angle Triangle relating to several Courses called a Traverse.

3. In an Oblique Triangle, in which are but 4 Cases, though there may be a multitude of various Questions; of which you have a Taste in Turning to Windward, and sailing in Currents. In 21 Problems.

IV. In Chapter 4th is *Mercator*'s sailing: to the right understanding of which, 'tis necessary to describe Mr. Wright's Projection, commonly known by the Name of *Mercator*'s Chart, and shew the uses of it, before I treat of the Problems of Sailing by it; which you will find performed in 12 Problems. In the first 9 the Table of Meridional Parts, or the Meridional Line on *Gunter*'s Scale is used. And in case that Table or Line be wanting to supply their room, I have added Problems of Sailing by the middle Latitude, which will nearly agree with *Mercator*'s Sailing, a thing of good use. In 4 Problems.

V. Spherical Trigonometry, or the Doctrine of Spherical Triangles rectangular and oblique, is next in order; and its being so necessary, you should understand how to make a spherical Triangle,

Triangle, and also how to measure any of its Parts, before the framing and working Proportions therein, I have fully explained that matter in the beginning of this Chapter, being in a manner a new Invention, I call Spherical Geometry: this you have in 21 Problems.

And in Spherical Trigonometry it self, (the next in order) you have all the Axioms and Cases, both in rectangular and obliquangular Triangles, explained with necessary Notes on each Case: as to know when a required Angle is Acute or Obtuse; and when a required Side is more or less than a Quadrant, in 12 Problems, containing 28 Cases.

VI. The Description and Use of both Globes is next to be considered; in which I have plainly and familiarly explained and shewed the use of the most necessary things belonging or relating to each of them: In 24 useful Problems.

To which is annexed a short Description and Use of the Hemispheres, projected on the Plain of the Ecliptick.

VII. Geography is the Subject of this Chapter, which is the application of Spherical Trigonometry in finding the True Distance of Places in the variety of their situation on the Globe of the Earth. In 4 Problems.

VIII. Great Circle Sailing comes next, which as it's the exactest way of sailing so it's the most difficult, and hardly possible for a Ship exactly to sail by; yet it's of great advantage to keep conveniently near it: for which purpose you'll find all that necessarily belongs or relates to it, both as to the Projective Part, and that both Stereographical and Gnomonical; as also in the Calculative Part, which is the application of both Spherical and Plain Trigonometry fully made out: with an intimation of shortning the Work by shewing how to describe the Arch of a Great Circle in a *Mercator*'s Chart. In 4 Problems.

IX. Next you have Spherical Trigonometry, applied in sundry Astronomical Problems useful in Navigation, wherein the Circles of the Sphere are described, and the necessary terms of Art explained to the meanest Capacity, with respect to the diurnal Motion; and that either,

1. According to the Ptolemaick System, wherein you have in a Right-angle Spherical Triangle, all the variety of Questions and Examples that relate to the Sun, with respect to his Longitude, Declination, right or oblique Ascension, or Descension; Rising, Setting; Amplitude, Altitude and Azimuth or the Hour of six; Altitude, Hour of the Day, when East or West;

Hour Azimuth, and Altitude, when he is in the Equinoctial. In 24 Problems. Also,

In an Oblique Spherical Triangle, you have great variety both with respect to the Sun or a Star, in many questions and examples relating to the Sun's Altitude, Azimuth, and Hour of the Day, in any Place, at any time of the Year: and relating to a Star; as to its Longitude, Latitude, Declination, right Ascension, Rising, Setting, Amplitude, Altitude, Azimuth Hour of the Night, its Altitude on the Meridian, and Time of its coming to it: In 12 Problems. Or,

2. According to the Pythagorean, or Copernican System; which is now generally received, as most agreeable to the observed experienced motion of the Heavenly Bodies; wherein Spherical Trigonometry is applied in variety of Questions and Examples relating to the Earth's Diurnal Motion about its own Axis, once in 24 Hours, whereby all the visible appearances of the Sun and fixed Stars are solved, with the description of the Circles of the Sphere, and how they are drawn Stereographically on the Plain of the Earth's Ecliptic. In 9 Problems.

X. Then follow very easy Rules to find the Variation of the Compass, and how to rectify the Compass, and to correct the Course thereby, both Arithmetically and Instrumentally, with great Readiness.

Also here you have the way of Projecting the Sphere Orthographical. In 2 Problems, with many Examples.

XI. An observation, either of Sun or Star; what it is, how or with what and when 'tis taken; with rules to find the Latitude of the Place of observation, and all the varieties therein reduced into one proposition, containing two general Cases, fully explained by many Examples.

XII. You have next the use of all the foregoing instructions, summarily comprehended in a new form of keeping a Sea-Reckoning or Journal, wherein the Log Book and Journal in words at length and tabular in figures, are kept together in one Book; whereby the whole proceeding, and every particular transaction of any voyage at all times may be seen and known, which will be no small satisfaction to those concerned in Ship and Goods, nor a little augmentation to the Mariner's credit and reputation.

And that so useful and beneficial a method might be practised by all who desire to keep a complete and exact reckoning, and to be enabled to render a good account thereof: I have largely described

described the form and manner of it, with plain Rules and Directions how to correct the Reckoning by the observed Latitude, and how to find what Latitude and Longitude the Ship is in every Day; with an example of Seven Days Journal: and how each Day's sailing is managed, in taking it from the Log-Board, casting it up, bringing it into one Course and Distance; with framing the Dead-Reckoning and setting it in the Journal. So by this the whole is made more intelligible.

Lastly, In the Tabular Part, you have first a Traverse Table, which tho' it stands in so little Room as two Pages, yet by it the Difference of Latitude and Departure from the Meridian, may be found for any Distance under 10,000 and for every Quarter Point of the Compass.

Next to that, A Table of Meridional Parts to every 5 Minutes of Latitude, which together with the Table of Proportionable Parts annexed, the Meridional Parts for each single Minute are found.

And next adjoining is a Table of 10,000 Logarithms,

After which you have a Triangular Canon Logarithmical, or a Table of Artificial Sines, Tangents and Secants, to every Degree and Minute of the Quadrant, which are corrected with more than ordinary care, there being none when this Book was first published in 1686, extant (in this Volume) that had Secants besides this. The description and general uses of these Tables are comprehended in four Chapters, containing 13 Propositions and set just before the Tables. At page 294.

The Schemes or Figures, are contained in 10 Copper-plates, inserted in their proper places, being orderly numbered with proper references for the more easy turning to any upon occasion.

Thus have you the sum of what's here treated, what my Labour and Pains have been herein, I leave you to judge who are most like to reap the Fruit and Profit (my Share being a very small Part) thereof; though I dare aver it's the completest and portablist pile of Instructions for a Young Learner of Navigation now extant: it's the very method I have used for now 50 Years, finding it ever successful even to the most indifferent Capacity among the many hundreds I have taught. Therefore if my Reader would be a Proficient herein, let him begin chearfully, and proceed gradually, and the end will crown his endeavours with answerable success.

Let not sloth persuade to give over at the meeting of any Difficulty, but rather remember that Love, Labour and Constancy will overcome the greatest Difficulty. And,

That

That my Learner may ſo read as to underſtand, and ſo underſtand as to be a Proficient, is the deſire (and where I am preſent is the endeavour) of him, who wiſheth the Young Student's Welfare, and the progreſs of Arts.

Near Cherry-Garden-Stairs on Rotherith Wall, in the 72d Year of my Age, 1717.

JAMES ATKINSON.

Epitome

Epitome of the Art of Navigation.

CHAP. I.

Practical Geometry explained by Definitions, Problems and Proportions.

GEometry is a Mathematical Science, explaining the kinds and properties of continued quantity or magnitude; that is; a Line, a Superficies, and a Solid, whose original is from a Punct.

Section. I. *Of Lineal Geometry, or the first kind of Magnitude.*

Definitions. 1. A Punct or Point, that is which cannot be divided into parts, and is the end of a Mathematical line: as the punct A. Plate 1. Fig. 1.

2. A Mathematical Line hath no breadth, or thickness, only length; it is made by the moving of a punct, and (considered in itself) is either regular or irregular.

3. Regular is either a right line or an arch.

4. A Right Line is the shortest distance between two puncts; as the line BC. Plate. 1. Fig. 1.

5. An Arch is not the shortest distance between two puncts, but bendeth evenly; as the arch DE.

6. Irregular is any crooked line that bendeth unevenly: as FG. Plate 1. Fig. 1.

7. Lines compared, are either parallel, or inclining; from whence proceed many problems.

Problem. 1. *To draw a line parallel to a given line.*

Definition. PArallel Lines, are of equal distance, and if infinitely produced, (being in the same superficies) will never meet: as the lines AB and CD. Plate 1. Fig. 2.

Example. AB the line } given
C is a Punct }

Through which punct C, and parallel to the line AB, a line is required to be drawn.

1. Take (with a pair of compasses) the nearest distance between the given punct C, and the line AB.

2. With

2. With that distance (in the compasses) and one foot of the compasses (any where in the line AB,) draw (that way the punct C lieth) an arch D.

3. From the punct C draw a line to touch the arch D, and its done, for the line CD, is parallel to the line AB, as was required.

Problem II. *To bisect or divide a given line into two equal parts.*

Example. AB is a given line. Plate 1. Fig. 3.
To find the middle thereof is required.

1. With any distance, (greater than half the given line AB, and one foot of the compasses on A, describe the arch CD.

2. With the same distance, and one foot on B, cross the former arch in C and D.

3. By C and D draw a line which will cut AB in E, the middle; and if AB is equal to EB, its done true; which point E is the middle of the line AB as was required.

Prob. III. *To erect a perpendicular from a punct in a given line.*

Definitions. 1. Inclining lines, are not of an equal distance, and if produced, will meet: as the lines AB, and CD. Plate 1. Fig. 4.

2. The meeting of inclining lines, (called an Angle) is either direct or oblique.

3. Direct-meeting of lines, is when the angles on each side are equal: as EGF, and GH; and this kind of meeting is called perpendicular. Pate 1. Fig. 4.

Example. AB, is a line given.
The punct A on one end of it, from whence to erect a perpendicular is required. As Plate 1. Fig. 5.

1. With any distance, and one foot in A, draw an arch to cut the line AB in D.

2. With the same distance, and one foot in D, draw an arch to cut the former arch in C.

3. With the same distance, and one foot in C, describe an arch DE, to cut the line AB in D.

4. By C and D draw a line, to cut the arch DE in E.

5. Then by A and E draw a line, and its done: for the line AE is perpendicular unto AB, as was required.

Problem IV. *To let fall a perpendicular, from a given punct to a given line.*

Example. AB is a line given; C is a given punct: from whence to let fall the perpendicular to the line AB, is required. Plate 1. Fig. 6.

1. Draw

1. Draw a line (at pleasure) from C to AB, as is the line CD.

2. By prob. 2 bisect the line CD in E.

3. With the distance EC, equal to ED, and one foot in E, cross the line AB in A.

4. By A and C draw a line, and it's done: for AC is a perpendicular let fall from the punct C, to the line AB as was required.

Prob. V. *To make a plain angle.*

Definitions. 1. The meeting of inclining lines is called an angle, and the lines so meeting are called sides of the angle; as AB and AC. Plate 1, Fig. 7.

2. An Angle is either a right angle, or an oblique angle.

3. A Right Angle is where two lines are perpendicular to each other; as ED and DF. Plate 1. Fig. 7.

Note, A Right Angle, is just 90 degrees.

4. An Oblique Angle is either acute less than 90; as BAC, or obtuse more than 90 degrees; GHI in Fig. 1. Plate 7.

Note, An angle is written with 3 letters, the middle letter signifieth the angular punct; BAC signifieth the angle A.

An Angle is measured by an Arch, whose center is the angular punct, and is drawn from the one side to the other of the angle, as the measure of the angle KLM is the arch NO, Plate 1. Fig. 7.

What a degree is you may see in *Prob.* 9. *Definition* 1.

Example 1. At A in the line AB, to make a right angle. Plate 1. Fig. 7.

The Rule upon A (by *Prob.* 3) erect the perpendicular AC, and it's done: for the angle BAC is a right angle.

Example 2. At A in the line AB, to make an acute angle equal to 41 degrees. Plate 1. Fig. 8.

1. Take (always) a chord of 60 degrees from your scale, and with one foot on A draw an arch DE, to cut the line AB in D.

2. Make the arch DE equal to the chord of 41 deg. that is, take 41 deg. from the same scale of chords, and lay it on the arch from D to E.

3. By A and E draw the line AEC, and it's done: for the angle BAC is an acute angle, containing 41 degrees.

Example 3. At B in the line BC, to make an obtuse angle equal to 102 degrees. Plate 1. Fig. 8.

1. As before (with one foot on B) draw the Arch EF with a chord of 60 deg. to cut BC in E.

2. On that arch make EG equal to GF, and each equal to 51d. the half of 102d. that is, take 51d. from the same Scale of Chords, and lay it on the arch from E to G, and from G to F.

3. By

3. By B and F draw the line BFD and it's done; for the angle CBD is an obtuse angle, containing 102 degrees.

Sect. II. *Of superficial geometry, or the second kind of magnitude.*

D*Efinitions.* 1. A superficies hath no thickness, only length and breadth, 'tis made by the moving of a line; and is either plain convex or concave.

2. A plain superficies, is a figure flat, smooth, and even, made by the motion of a right line, its either simple or various.

3 A { simple / various } Figures or superficies is bounded by { one line / or lines.

4. A Figure bounded by one line, is either a circle or an ellipsis.

5. A Figure bounded by lines, is either a triangle, a quadrangle or a multangle.

6. In every superficies there are three things to be noted.

1. The Term, which is that line, or lines bounding it; as BCDEB. Plate 1. Fig. 9.

2. The Center, which is a punct in the middle of it, as A.

3. The Area, which is all the space contained within the term, as ABCDEBA. Plate 1. Fig. 8.

7. The kinds of plain figures are seven, a Circle, a Triangle, a Quadrangle, and a Multangle, the most easy to make; the more difficult are the Ellipsis, Parabola, and Hyperbola; each affords divers Problems, of which we begin with the circle.

Prob. VI. *To describe a circle, having its diameter given.*

Definitions 1. A Circle is a plain figure bounded by one line, called the periphery; as ABCDEBA. Plate 1. Fig. 9.

2. The Periphery of a circle, is a line compassing it; so that its equally distant from the center, as BCDEB.

3. The Center of a circle is a punct in the middle of it; from whence all right lines drawn to the periphery are equal, and called radius; as A.

4. The Diameter of a Circle, is any right line drawn through the Center to the Periphery; it bisecteth the circle, and is the longest right line can be drawn in it; as BAD is a diameter.

Example. BD equal to 60 inches is given, to make a circle on or about it, is required. Plate 1. Fig. 10.

1. Bisect (by Prob. 2.) the line BD in A.

2. With the distance AB equal to AD, and one foot on A, describe the periphery BCDEB, and it's done.

Prob. VII. *To draw the periphery of a circle through any three puncts not in a right line.*

Example. BC and D are three puncts given, through them to draw the periphery of a circle is required. Plate 1. Fig. 11.

1. With

1. With any distance (greater than half CB, or CD) and one foot in C, draw an arch FGHI.

2. With the same distance, and one foot in B, cross that arch in F and G.

3. Likewise (with the same distance) and one foot in D, cut the former arch in H and I.

4. By F and G, and H and I, draw lines to cut each other in A the center.

5. With the distance AB, equal to AI, equal to AD, and one foot on A, draw the periphery BCDB, and it's done.

Prob. VIII. *To quarter a circle, or in a circle to draw two diameters at right angles.*

Example. BCDEB the periphery, and A the center of the given circle. In which to draw two diameters at right angles is required. Plate 1. Fig. 12.

1. Through the center A, draw the diameter BAD.

2. Bisect (by Prob. 2.) BAD, by drawing the line CAE, and it's done. And if BC, CD, DE, and EB are equal to each other, it's done true; otherwise not.

Prob. IX. *To find the chord, sine, tangent, and secant of an arch of a circle.*

Definitions. 1. If the Periphery of a circle be divided into 360 equal parts, they are degrees; a degree divided into 60 equal parts, are minutes; a minute into 60 equal parts, are seconds, &c. Plate 1. Fig. 13.

2. The arch of a circle is any part of the periphery; as EB, or EBF; and is counted in degrees, which are greater or lesser in proportion to the radius of the circle.

3. Radius of a circle is half its diameter, or any right-line drawn from the center to the periphery: as AB.

4. A Chord-line is drawn from one end of an arch to the other; as EDF, or EB, are chord-lines.

5. A Sine-line is half a chord-line of double the arch: as ED (being half the chord EDF) is sine of the arch BE, and DF the sine of BF.

6. A Versed Sine-line is between the sine-line and the periphery, as DB is the versed sine of the arch BE.

7. Tangent toucheth the periphery, and is perpendicular to a diameter in the touch punct: as BC is a Tangent line of the arch BE.

8. Secant cutteth the periphery, being drawn from the center, till it meet the tangent: as AC is secant of the arch BE.

Example. The chord, sine, tangent, and secant of 45 degrees is required. Plate 1. Fig. 13.

1. With any distance (and one foot on A) describe the periphery HIBG.

2. Quarter

2. Quarter the periphery (by prob. 8.) by drawing the two diameters HAB and IAG; then is BG equal to GH, equal to HI, equal to IB, equal to 90 degrees.

3. Divide (by prob. 2.) BI into two equal parts in E, and then BE equal to EI is equal to 45 degrees

4. Make BF equal to BE, and draw the lines BE, and EDF, to cut the diameter HAB in D.

5. At B (by prob. 3.) erect BC perpendicular to the diameter HAB; or draw (by problem 1.) BC parallel to the diameter IAG.

6. By A and E draw a line to cut BC in C, and it's done.

Then the line BE is the chord of 45 deg. the line EDF the chord of 90 deg. the line ED equal to DF, the sine of 45 deg. DB the versed sine, BC the tangent line, and AC the secant line of the same arch BE, equal to 45 degrees.

This problem is the ground work of the line of rhombs. Chords, sines, tangents, secants, &c. set on rulers called scales: as also of the degrees on the quadrant or cross-staff, and other mathematical instruments.

But its chiefest use is in a right angle triangle, as shall be shewed in trigonometry, when I come to explain the first Axiom in making any side Radius, to which you are referred.

Of triangles the second kind of plain figures.

Definition 1. A Triangle is any three corner Figure, having three Sides and three Angles, as ABC; and in respect of its Angles is either rectangular or obliquangular. Plate 1. Fig. 14.

2. A Right-angle Triangle hath one Right-angle; in its making hath a perpendicular erected, or let fall: as ACB.

3. Those sides containing the right angle are called legs: as leg. AB, and leg. BC. Plate 1. Fig. 14.

4. The side opposite to the right angle is called the hypotenuse: as AC. Plate 1. Fig. 14.

Prob. X. *To make a right angle triangle, the hypotenuse and one angle given.*

Note 1. The three angles of every plain triangle (together) are equal to 180 degrees.

2. To make a right angle triangle two things (besides the right angle) and one side, must be given.

Example. The $\left\{ \begin{array}{l} \text{hypotenuse AC 137 feet} \\ \text{angle BAC 34d. 30m.} \end{array} \right\}$ given.

With them to make a right angle triangle is required. Plate 1. Fig. 15.

1. Make the angle BAC equal to 34d. 30m. (by Prob. 5. Examp. 2) that is, take a chord of 60d. and with one foot on A,

A, draw an arch, and on that arch lay a chord of 34d. 30m. drawing AB, and AC, which includes the angle BAC equal to 34d. 30m.

2. Make AC equal to 137 feet; that is, from any ſcale of equal parts take 137, and lay it from A to C.

3. From C (by Prob. 4.) let fall the perpendicular BC, to cut the line AB in B, and it's done.

Prob. XI. *To make a right angle triangle; the hypotenuſe and one leg given.*

Example. The {hypotenuſe AC 411 / leg. AB——— 342} perches given.

With them to make a right angle triangle, is required. Plate 1. Fig. 16.

1. Make AB equal to 342 perches; that is, from any Scale of equal parts take 342, and lay it from A to B.

2. At B (by Prob. 3.) erect a perpendicular BC.

3. With 411 perches: (that is, take 411 from the ſame ſcale of equal parts, the 342 was taken) and with one foot cut the perpendicular in C.

4. From A to C draw a line and it's done.

Prob. XII. *To make a right angle triangle, one leg and one angle given.*

Examp. The {leg AB 415 Miles / angle BAC 40d. 25m.} given

With them to make a right angle triangle is required by Plate 1. Fig. 17.

1. Make AB equal to 415 miles, that is, from any Scale of equal Parts, take 415, and lay it from A to B, and at B (by Prob. 3.) erect a perpendicular BC.

2. At A (by Prob. 5. Example 2.) make the angle BAC equal to 40d. 25m. (which is thus; take a chord of 60d. and with one foot on A, draw an arch, on which arch lay the chord of 40d. 25m.) by drawing the line AC, and it's done.

Prob. XIII. *To make a right angle triangle, the legs given.*

Examp. The leg. {AB 404 / BC 328} leagues given.

With them to make a right angle triangle, is required. Plate 1. Fig. 18.

1. Make AB equal to 404 leagues. And at B (by Prob. 3.) erect a perpendicular BC.

2. Upon the perpendicular, make BC equal to 328 leagues, and from A to C draw a line and it's done.

Of oblique-angles triangles.

Definition 1. An oblique-triangle hath three oblique angles, and is either an obtuſe or an acute triangle.

2. An obtuſe triangle hath one obtuſe angle, that is, one angle more than 90d. as BCD. Plate 1. Fig. 19.

3. An acute triangle hath all its three angles acute; that is, each angle is leſs than 90d. as EFG. Plate 1. Fig. 19.

Note, To make an oblique triangle, three things, (and one of them a ſide) muſt be given.

Prob. XIV. *To make an oblique triangle, two angles and one ſide oppoſite given.*

$$\textit{Exam.}\ \text{The}\left\{\begin{array}{l}\text{angle}\left\{\begin{array}{l}\text{BCD 114d.}\\ \text{BDC 26d. 40m.}\end{array}\right.\\ \text{ſide BC 352 miles.}\end{array}\right\}\text{given.}$$

With them to make an oblique triangle is required. Plate 1. Fig. 19.

1. Make BC equal to 352 miles. And at C (by Prob. 5. Examp. 3.) make the angle BCD equal to 114d. by drawing the line CD: that is, take a chord of 60d. and with one foot on C, draw an arch, on that arch lay the chord of 114d. by taking its half 57d. and laying it twice on the arch, by which draw the line CD, thereby you'll conclude the angle BCD 114 degrees.

2. Add 114d. and 26d. 40m. its 140d. 40m. the ſum of the given angles, which ſubſtract from 180d. 00m. the ſum of the three angles.

Remainder is the angle CBD———39d. 20m.

3. At B (by Prob. 5. Example 2.) make the angle CBD equal to 39d. 20m. by drawing the line BD: that is, with a chord of 60d. and one foot on B, draw an arch, on that arch, lay the chord of 39d. 20m. by which draw the line BD, and it's done.

Prob. XV. *To make an oblique triangle, two ſides and one angle oppoſite given.*

$$\textit{Example.}\ \text{The}\left\{\begin{array}{l}\text{ſide}\left\{\begin{array}{l}\text{BC 274}\\ \text{BD 426}\end{array}\right\}\text{miles}\\ \text{angle BCD 108d. 30m.}\end{array}\right\}\text{given.}$$

With them to make an oblique triangle is required. Plate 1. Fig. 20.

1. Make BC equal to 274 miles, and at C (by Prob. 5. Exam. 3.) make the angle BCD equal to 108d. 30m. by drawing the line CD.

2. With

2. With 426 miles and one foot in B, cut the line CD in D, and by B and D draw a line, and it's done.

Prob. XVI. *To make an oblique triangle, two sides, and an included angle given.*

Example. The $\left\{ \begin{array}{l} \text{side} \left\{ \begin{array}{l} \text{BC } 327 \\ \text{BD } 274 \end{array} \right\} \text{ feet} \\ \text{angle CBD } 101\text{d. } 30\text{m.} \end{array} \right\}$ given.

With them to make an oblique triangle is required. Plate 1. Fig. 21.

1. Make the side BC equal to 327 feet. And at B (by Prob. 5. Exam. 3.) make the angle CBD equal 101d. 30m. by drawing the line BD.

2. Make BD equal to 274 feet; and by C and D draw a line, and it's done.

Prob. XVII. *To make an oblique triangle, three sides given.*

Note; Any two sides must be greater than the third, to make a triangle.

Example. The side $\left\{ \begin{array}{l} \text{BD } 525 \\ \text{BC } 425 \\ \text{CD } 250 \end{array} \right\}$ leagues given.

With them to make an oblique triangle is required. Plate 1. Fig. 22.

1. Make BD equal to 525 leagues. Then with 425 leag. and one foot in B draw an arch C.

2. With 250 leagues and one foot in D, cut the arch in C, and from C draw lines to B, and to D, and it's done.

Sect. III. *Of proportions for ready measuring superficies and solids.*

HAving shewed the making the most common and useful Geometrical Figures, I now proceed to their (and others) mensuration, by exact and easy rules.

Now to prevent the book's swelling too great, I'll not trouble you with arithmetical calculation, but present you with an instrumental way of operation, that's quick and true, easy and ready, on Gunter's-Scale, an instrument so very well known, it needs the less description: only to avoid repetitions take this excellent rule.

A general rule for Gunter's-Scale.

Extend the compasses from the first term (in a geometrical proportion) to the second; that extent (if rightly laid) from the third, will reach the fourth term, or thing required.

This rule well minded, will make what follows appear eaſy, and ſave many words and much time; and therefore to explain it, take this proportion.

As 2 is to 6, ſo is 5 to 15; which I ſhorten thus;

2.. 6:: 5.. 15

The extent (on the Line of Numbers) from 2 unto 6, (according to the ſaid General Rule) will reach from 5, to 15 the fourth term and thing required.

These words may be ſpared by the ſhort way of writing the proportion and minding the order of the terms, as in the problems following. But for a full explanation of the Gunter, and how to work any proportion by it, ſee my addition to Mr. Wakeley's Mariner's Compaſs rectified. Page 181, &c.

Prob. XVIII. *The diameter of a circle given; to find it's periphery.*

The rule. As $\left\{\begin{matrix}7\\1\end{matrix}\right\} \cdot \left\{\begin{matrix}22\text{———}\\3{\cdot}14159\end{matrix}\right\}$ :: diameter periphery.

Example. The diameter 34 inches: what is the periphery?

Anſw. Inches 106.8 tenths of an inch. For,

As $\left\{\begin{matrix}7\\1\end{matrix}\right\} \cdot \left\{\begin{matrix}22\text{————}\\3{\cdot}14\text{———}\end{matrix}\right\}$ :: 34 inches .. 106.8 tenths.

That is, the extent of the compaſſes (on the Line of Numbers) from 7 to 22, or from 1 to 3, 14, &c. will reach from 34 inches to 106.8 inches neareſt. Obſerve the like in all the reſt.

Prob. XIX. *By the periphery to find the diameter.*

The rule. As $\left\{\begin{matrix}22\text{———}\\3.14159\\1\text{:———}\end{matrix}\right\} \cdot\cdot \left\{\begin{matrix}7.\text{———}\\1.\text{———}\\0{\cdot}3183\end{matrix}\right\}$ :: Periph. . dia.

Examp. Periphery inches 106.8tenths, what is the diameter. *Anſwer,* Inches 34 for 22.. 7 :: inches 106.8.. 34 inches the diameter required.

Prob. XX. *The diameter of a circle given, to find it's area or content,*

The Rule. $\left\{\begin{matrix}\text{1. Find its periphery by Prob. 18. then ſay,}\\\text{2. As 1 .. } \tfrac{1}{2} \text{ diameter : : } \tfrac{1}{2} \text{ periphery . . area.}\end{matrix}\right.$

Example. The diameter 14 inches; what is its area? *Anſwer.* 154 inches.

By Prob. 18. The diameter being 14, the periphery is 44 inches, and by the rule it is thus:

As 1 .. 7 :: 22 .. 154 inches the area or content required.

Prob.

Prob. XXI. *By the periphery to find the area.*

The Rule. $\begin{cases} \text{1. Find the diameter by Prob. 19. And then,} \\ \text{2. The area is found by Prob. 20.} \end{cases}$

Example. The periphery 22 feet: what is the area? *Answ.* Feet 38.5 tenths.

The periphery 22 inches, the diameter is 7 inches by Prob. 19.

And by Prob. 20, it is thus, as 1 .. 3.5 :: 11 .. inches 38.5, the area required.

Note, The area is of the same name with the dimensions taken: That is, if the diameter and periphery be inches, feet, or yards, &c. then the area is inches, feet, or yards, &c.

Prob. XXII. *To reduce the area or content of any thing found in inches, to feet; or to gallons, beer, or wine.*

1. *Rule for feet;* say, 144 .. 1 :: area in inches .. area in feet.

2. *Rule for Gallons* As $\begin{Bmatrix} 282 \\ 231 \end{Bmatrix}$ .. 1 :: area in inches .. $\begin{Bmatrix} \text{Beer} \\ \text{Wine} \end{Bmatrix}$ Gallons.

This needs no Example; and to avoid the first Rule, take dimensions in Foot-measure that is, 12 Inches or a Foot divided decimally: that is, into 100 equal parts, called the Line of Foot-measure.

Prob. XXIII. *The diameter, or periphery of a circle given, to find the side of the inscribed square, or the chord of 90 deg.*

The rule. As 1 .. $\begin{Bmatrix} .707 \\ .225 \end{Bmatrix}$ :: $\begin{Bmatrix} \text{Diamet.} \\ \text{Periph.} \end{Bmatrix}$ .. Side of the inscribed square, or chord of 90d. required.

Example. The diameter of a circle being feet 34 tenths; what is the side of the inscribed square, or the chord of 90 degrees? *Answ.* Feet. 2.4038 parts of 100.

For; as 1 .. 0.707 :: 3.4 .. 2.4038 the chord of 90 deg. or side of the inscribed square.

Prob. XXIV. *The base and perpendicular of a triangle given, to find the area.*

The rule. As 1 .. $\frac{1}{2}$ base :: perpendicular .. area required.

Exam. The base 16 inches, and the perpendicular 12 inches: I demand the area? *Answ.* 96 inches.

For; as 1 .. 8 :: 12 .. 96 the area required.

Prob. XXV. *The length and breadth of a parallelogram given; to find it's area*

Definition. 1. A quadrangle hath four angles, and four sides as ABCD; and is either a parallelogram or a trapezia. Plate 1. Fig. 23.

2. A Parallelogram hath its oppoſite ſides parallel and equal as ABCD; and is either a ſquare, a long ſquare, a rhombus, or rhomboides; the firſt two are rectangle parallelograms, the latter are obliquangled parallelograms.

3. A Square hath four equal ſides, and four equal angles; as ABCD. Fig. 23.

4. A Long Square, hath but two ſides equal, and four equal angles; as EFGH. Fig. 24.

5. A Rhombus, hath four equal ſides, and but two oppoſite angles equal; as IKLM. Fig. 25.

A Rhomboides, hath only two oppoſite ſides, and two oppoſite angles equal, as NOPQ. Fig. 26.

Note, The breadth of the two laſt is not IM nor NQ, but the perpendicular MN, and QR, and to meaſure all parallelograms, obſerve this General Rule.

As 1 ∵ Breadth :: length ∵ area required.

Examp. 1. A ſquare whoſe length AB, and breadth BC, each is Feet 2. 5 tenths: what is the area? *Anſ.* Feet 6. 25 parts of 100. For, as 1 ∵ 2. 5. :: 2. 5. ∵ 6. 25. area. Fig. 23.

Examp. 2. A long ſquare whoſe length EF, is feet 2. 5. and breadth FG is feet 1. 6: what is the area? *Anſw.* 4 Feet.

For, As 1 ∵ 1.6 :: 2. 5 ∵ 4 feet area. Plate 1. Fig. 24.

Examp. 3. A rhombus whoſe length IK is feet 2. 5 and breadth MN feet 1. 6: what is the area? *Anſw.* Feet 4.

Plate 1. Fig. 25.

For; As 1 ∵ 1.6 :: 2.5 ∵ 4 area required.

Exam. 4 A rhomboides whoſe length NO is feet 25, and breadth QR feet 12. what is its area? *Anſw.* 300.

For, as 1 ∵ 12. :: 25 ∵ 300 area required. Plate 1. Fig. 26.

Prob. XXVI. *The Diagonal and two perpendicular of a trapezia given; to find its area.*

Definition 1. A Trapezia, hath its oppoſite ſides and its oppoſite angles equal: as ABCD. Plate 1. Fig. 27.

2. The Diagonal, is a line drawn from its oppoſite angles, as AC.

3. The two perpendiculars, are let fall from the angles to the diagonal, as BE, DF.

The area of a trapezia, is found by this rule.

As 1 ∵ $\frac{1}{2}$ diagonal :: ſum of the perpendiculars ∵ area are req.

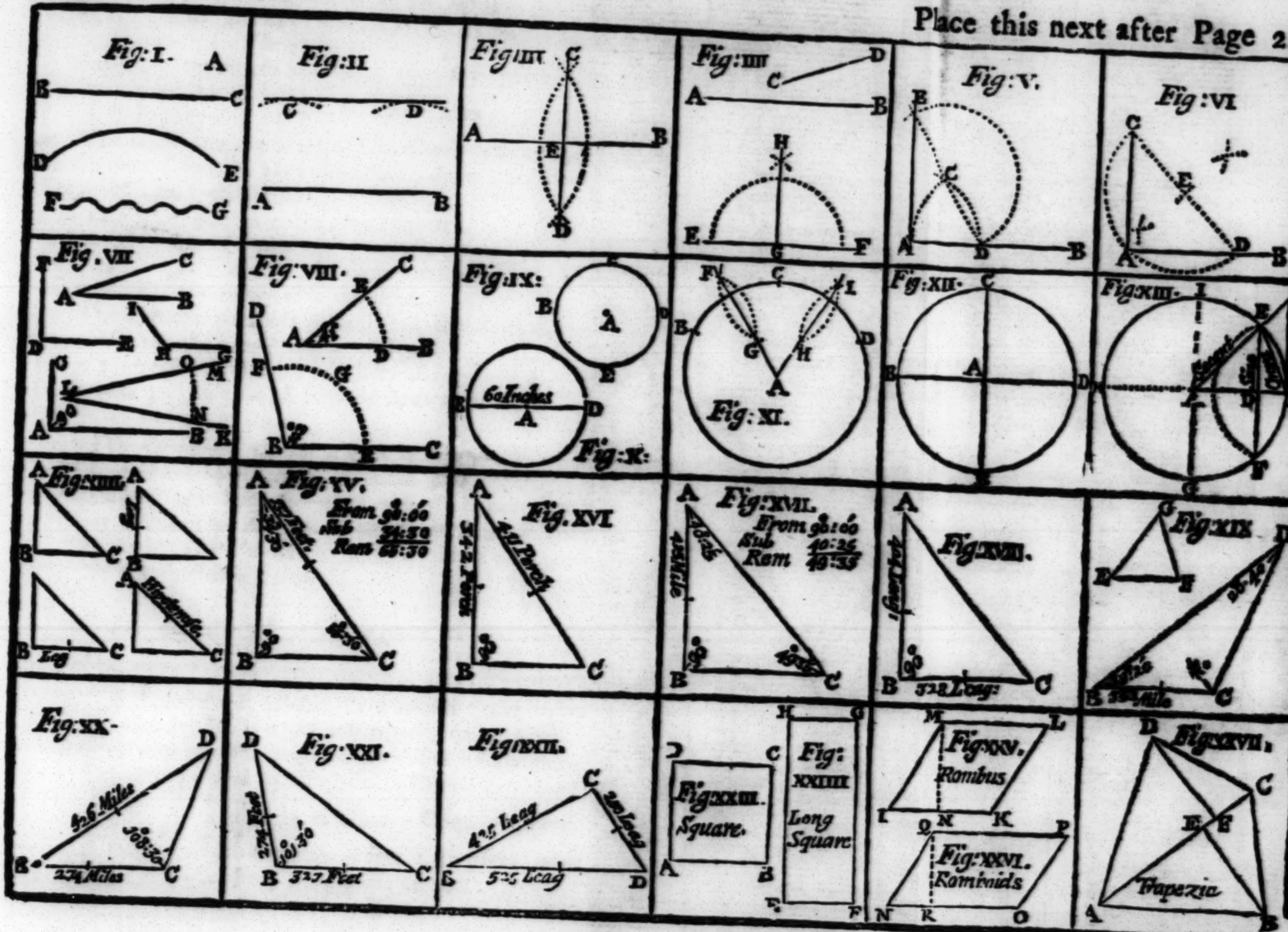
Examp. The diagonal AC 28 feet; the perpendicular BE 15 feet, and DF 12 feet: what is its area? *Anſw.* 378 feet.

For, as 1 ∵ 14 :: 27 ∵ 378 feet the area required. Plate 1 Fig. 27.

Prob.

Plate I.

Place this next after Page 22.



Prob-

Prob. XXVII. *The length and breadth of an Ellipsis called an oval given, to find the area.*

The rule.

As 1 ·· breadth :: length 4th number : then say again.

As $\left\{ \begin{matrix} 14 \\ 1 \end{matrix} \right\}$ ·· $\left\{ \begin{matrix} \cdot 11 \text{———} \\ \cdot 78539 \end{matrix} \right\}$ ::4th number ·· area required.

Exam. The transverse diameter of an ellipsis 12 feet, and conjugate diameter 8 feet. What's the area? *Answ.* 75 $\frac{4}{10}$ feet.

For, as 1 ·· 8 :: 12 ·· 96 the fourth number.

Then as 14 ·· 11 :: 96 ·· 75. 4 the area required.

Prob. XXVIII. *To find the area of a parabola.*

The rule. As 1 ·· axe :: double ordinate ·· 4th number; then say again, as 3 ·· 2 :: 4th number ·· area required.

Examp. The axe of a parabola 9 feet, and the double ordinate 8 feet. What's the area? *Answ.* 48 feet.

For;—as 1 ·· 9 :: 8 ·· 72 the 4th number.

And then;——as 3 ·· 2 :: 72 ·· 48 feet the Area required.

Sect. IV. *Of solids, the third kind of magnitude.*

DEfinition. A Solid hath length, breadth and depth; and if bounded by one Superficies, is either a Sphere, or a Spheriod; but bounded by more than one Superficies is either a Prism, a Pyramid, a Prismoid, or a Pyramidoid; or compounded of the last, called a Spinale.

Prob. XXIX. *The diameter of a sphere given, to find the solid content.*

Definition. A Sphere or Globe, is a round Solid, whose length, breadth and depth, is alike and equal; being made by the Rotation, or moving of a Semi-Circle about its Diameter; whose Solid Content is found by this rule.

As $\left\{ \begin{matrix} 21 \\ 1 \end{matrix} \right\}$ ·· $\left\{ \begin{matrix} 11 \text{....} \\ .523599 \end{matrix} \right\}$ :: Cube of Diam ·· Cont. required.

Example. A Sphere whose diameter is feet 2. 42 parts, what's the Solid Content? *Answ.* Feet 7. 43 parts of 100.

For;———as 1 ·· 2. 42::2.42 ·· 5.86::5.86 ·· 14.17 the Cube of the Diameter; then, feet.

As $\left\{ \begin{matrix} 21 \\ 1 \end{matrix} \right\}$ ·· $\left\{ \begin{matrix} 11 \\ 0524 \end{matrix} \right\}$ ::14.17 ·· 7.43 the Content required.

In such cases as this, the readiest way is to extend the compasses from the first term to the third term; and that being turned over three times from the second term will reach the thing required.

As here, the extent from 1 to the Diameter 2·42 turned three times from 0·524, &c. reacheth to feet 7·43 parts of 100, the content required. For it's thus;

1 ·· 2·42 :: 0·524 ·· 1·27 :: 1·27 ·· 3·07 :: 3·07 ·· 7·43 that is,

The extent from 1 to 2·42 (on the Line of Numbers) will reach from 0·524 to 1·27; and the same extent will reach from 1·27 to 3·07; and the same extent from 3·07 reacheth to feet 7·43 parts of 100.

Prob. XXX. *The diameter of a spherion given, to find the solid content.*

Definition. A Spheriod is an Oval Solid, longer than it is broad or deep; being made by the Rotation of a Semi-Ellipsis about it's diameter; the Solid Content is found by this.

Rule As 1 : Square of Depth :: Length ·· a 4th Numb. then say,

As $\left\{\begin{matrix}21\\1\end{matrix}\right\}$ ·· $\left\{\begin{matrix}11\\524\end{matrix}\right\}$ :: 4th Number ·· Content required.

Examp. A Spheriod whose

length or transverse / depth or conjugate $\Big\}$ Diameter is Inches $\left\{\begin{matrix}7·2\\4·1\end{matrix}\right\}$ Tenths.

What's the Solid Content? *Answ.* Inches 63·4 Tenths.

For it's, as 1 ·· Square 4·1 :: 7·2 ·· 121; here the extent from 1 to 4·1 is turned twice from 7·2 and it reacheth 121 Then say,

As $\left\{\begin{matrix}21\\1\end{matrix}\right\}$ ·· 121 :: $\left\{\begin{matrix}11.\\·524\end{matrix}\right\}$ ·· $\Big\{$ Inches 63·4 tenths, the content required.

Or thus; as 1 ·· 4·1 :: 0·524 ·· 215 :: 215 ·· 8·81;

That is, the extent on the Line of Numbers from 1 to 4·1 will reach from 0·524 to 2·15; and the same extent from 2·15 8·81 parts of 100.

Then; as 1 ·· 8·81 :: 7·2 ·· 63·4; that is, the extent from 1 to 8·81, will reach from 7·2 to Inches 63·4 Tenths of an inch, the content required.

Prob. XXXI. *The dimensions of a prism given; to find the solid content.*

Definition 1. A Prism, is a strait solid, whose two bases or ends are equal, parallel, alike, and alike situate.

2. A Prism, takes its Sir-Name from its Base; as a round Prism, a Triangular, a Quadrangular, or a Multangular Prism, all are measured by this one General Rule.

As 1 ·· Area of one Base :: Length ·· Solid Content.

Examp. 1. A Round Prism called by some a Cylinder, whose Diameter at each end is —— 21 / and length is —————— 30 $\Big\}$ Inches.

What's the Solid Content? *Answ.* 10392 inches.

A Cylinder's two Bases are two equal Circles, and therefore the Area of its base is found by Prob. 20 to be Inches 346.4 Tenths: then it is,

As 1..346.4::30¨10392 Inches, Content required.

Examp. 2. An Elliptick Prism, whose Bases being equal Ellipses, their

Transverse } Diameter is Inches { 12.
Conjugate } { 8.

And length of the Solid is Inches 30.

What's the Solid Content? *Ans.* Inches 2262.

For its base being an ellipsis, the area by Prob. 27. is 75.4. inches, and then it is,

As 1¨75.4::30¨2262 inches the solid content required.

Examp. 3. A triangular prism, whose bases are two equal triangles, in each of which

The { Base } is inches { 16.
{ Perpendicular } { 12.

And the length of the solid is inches 20.

What's the solid content? *Answ.* Inches 1920.

The area of the base (by Prob. 24) is 96 inches: and then its

As 1¨96::20..1920 inches, solid content required.

Examp. 4. A cube (which is a quadrangle prism, of equal length, breadth and depth, being cloathed with six equal squares) whose sides are inches 12; what's the solid content?

Answ. Inches 1728.

For as one ¨ square of 12::12¨1728. That is, the extent from 1 to 12 turned over two times from 12, reacheth to inches 1728 the solid content required.

Examp. 5. Parallelepepidon, or a quadrangle prism, whose bases are two equal squares of each one,

Side } is feet { 1.25 } parts of 100
Length } { 21.75 }

What's the solid content? *Answ.* Feet 33. 9, tenths.

For; As 1¨square of 1.25::21. 75.. feet 33.9, that is, the extent from 1 to 1. 25, being turned two times from 21. 75 will reach to feet 33.9 the solid content required.

Examp. 6. A parallelepepidon, or a quadrangle prism, whose bases are two equal long squares, in each,

The { breadth is——1.6 }
{ depth is———2.5 }
The length of the solid 15.5 }

What's the solid content? *Answ.* Feet 62.

For it is as 1¨1.6::2.5¨4 area of the base.

Then; as 1¨4::15.5¨62 feet, solid content required.

In

In the like manner may the solid content of any prism be found, let its base be of what form soever; for its area may be found by Problem 20, 21, 22, 23, 24, 25, 26, or 27, and the solid content of the prism, by the general rule in the Prob. 31.

Prob. XXXII. *The dimensions of a pyramid given; to find the solid content.*

Definition 1. A Pyramid is a strait Solid, having one Base, and at t'other end a punct, called the Vertex.

2. A Pyramid takes its sir-name from it's Base; as a Round, an Elliptick, a Triangular, a Quadrangular, or a Multangular Pyramid; all are measured by this one General Rule

As 3.. Area of Base :: Length ·· Solid Content.

Note, By Length understand a Perpendicular from the Vertex to the Base; and not the length of the Pyramid on its outside from Vertex to Base.

Examp. A Round Pyramid, called by some a cone, whose diameter at base———21 } Inches.
perpendicular at length——30 }

What's the Solid Content? *Answ.* 3465 inches.

For the Area of the Base is Inches $346\frac{5}{10}$ by Prob. 20.

And

Then; as 3·· 346·5::30··3465 Inches, which is the Solid Content required.

The like do for any other Pyramid, which I pass over, having given six Examples in a Prism, and leave you to apply them here.

Prob. XXXIII. *The dimensions of a prismoid given, to find its solid content.*

Definition 1. A Prismoid is a strait Solid having two unequal Bases or Ends, but are parallel, like, and alike situate.

2. A Prismoid, is as various as a Prism, and is no other than the Frustum of a Pyramid.

3. Frustum of a Pyramid, is the lower part of it, when the upper part is cut off parallel to the Base; and all of them may be measured by this General Rule.

1. Multiply the Area of each Base together, and from the product extract the Square Root.

2. Add the Area of each Base, and that Square Root into one sum; then,

3. Say, as 3·· that Sum :: Length··Solid Content.

But

But for a Square Prismoid, take this particular Rule.

1. To the Square of each Side, add the Product of the Sides into one Sum; then,

Say, as 3 .. that Sum :: Length .. Solid Content.

And for a Round Prismoid, this is the Rule.

1. Add the square of each diameter, and the product of the diameters into one sum; and then,

2. Say, as 3.82.. that sum :: Length..solid content.

Or more largely thus: As 3.8197, is to the foresaid sum, so is the length of the solid content.

Examp. 1. *A square prismoid (or the frustum of a square pyramid) whose*

$$\left.\begin{array}{l}\text{greatest}\\ \text{lesser}\end{array}\right\}\text{side is inches}\left\{\begin{array}{l}15\\ 9\\ 60\text{ inches.}\end{array}\right.$$
perpendicular length

What's the solid content? *Answ.* 8820 inches.

$$\text{For as } 1 \,..\left\{\begin{array}{c}15\\ 9\\ 9\end{array}\right\} :: \left\{\begin{array}{c}15\\ 9\\ 15\end{array}\right\} .. \left\{\begin{array}{l}2.25 \text{ square}\\ 0.81 \text{ square}\\ 1.35 \text{ product}\end{array}\right.$$

Sum of the two squares and product is 441 inches.

Then, as 3 .. 441 :: 60 .. 8820, solid inches required.

Examp. 2 *A round prismoid (or the frustum of a cone) whose*

$$\left.\begin{array}{l}\text{greatest}\\ \text{lesser}\end{array}\right\}\text{diameter is feet}\left\{\begin{array}{l}1.5\\ 0.9\\ 6.0\end{array}\right\}\begin{array}{l}\text{tenths}\\ \\ \text{feet}\end{array}$$
perpendicular length

What's the solid content? *Answ.* 69. 25 parts of 100.

$$\text{For, as}\,..\left\{\begin{array}{c}1.5\\ 0.9\\ 0.9\end{array}\right\} :: \left\{\begin{array}{c}1.5\\ 0.9\\ 1.5\end{array}\right\} .. \left\{\begin{array}{l}2.25\\ 0.81\\ 1.35\end{array}\right\}\begin{array}{l}\text{square}\\ \text{square}\\ \text{product}\end{array}$$

Sum of the two squares and product 4. 41 inches.

Then as 3.82 .. 441 :: 60 .. 69.25, solid inches required.

Example 3. *An elliptick prismoid, or the frustrum of an elliptick cone, whose*

greatest diameter at top, inches, 7.5
least diameter at top ——— 5
greatest diameter at bottom —— 8.7 tenths
least diameter at bottom——— 5.8
perpendicular length——— 47.0

What's

What's the solid content? *Answ.* 1617 inches. For,

As 1 ·· $\left\{\begin{matrix}5.\\5.8\end{matrix}\right\}$ :: $\left\{\begin{matrix}7.5\\8.7\end{matrix}\right\}$ ·· $\left\{\begin{matrix}37.5 \text{ area of top long-square.}\\50.46 \text{ area at bottom.}\end{matrix}\right.$ And,

as 1·· 37.5::50.46·· 1892.25 whose square root is ——— 43.5
area at top ——— 37.5
area at bottom ——— 50.46

sum is ——— 131.46

Then; as 3.82 ·· 131.46::47 ·· 1617 solid content in inches required.

If the bases of the foresaid prismoid had been long squares the work is the same, except only in the last proportion; and having the same dimensions, its solid content is inches 2060, very near; for it is thus;

As 3 ·· 131.46::47 ·· 2059.5 inches solid content.

Prob. XXXIV. *The dimensions of a pyramidoid given; to find its solid content.*

Definition. 1. A Pyramidoid is not a strait solid, it hath one Base, and at t'other end a punct called the vertex; but the outside from base to vertex, is convex, either spheroidical, parabolical, or Hyperbolical, &c.

2. A Pyramidoid, takes its sir-name from its base and outside; as a spheroidical, parabolical, or hyperbolical round pyramidoid; and so of the rest, as in a pyramid; all may be measured by this one general rule.

As 1.5 ·· area of the base :: length ·· solid content, when a spheroidical pyramidoid; but if

$\left.\begin{matrix}\text{parabolical}\\\text{hyperbolical}\end{matrix}\right\}$ the first term is $\left\{\begin{matrix}2.\\2.4.\end{matrix}\right.$

Examp. A round pyramidoid, called by some a conoid, whose

$\left.\begin{matrix}\text{diameter at the base ——— 21}\\\text{perpendicular length ——— 30}\end{matrix}\right\}$ inches

What's the solid content if $\left\{\begin{matrix}\text{Spheroidical?}\\\text{Parabolical?}\\\text{Hyperbolical?}\end{matrix}\right\}$ *Answ.* $\left\{\begin{matrix}6930.\\5197.5.\\4331.2.\end{matrix}\right.$

The area of the base is inches 146.5 tenths, by Prob. 20.

And then 'tis

As $\left\{\begin{matrix}1.5\\2.\\2.4\end{matrix}\right\}$ ·· 146.5 :: 30.. $\left\{\begin{matrix}\text{6930. Spheroidical}\\\text{5197.5 Parabolical}\\\text{4331.2 Hyperbolical}\end{matrix}\right\}$ Cont. in Inches

More

More examples I think here needless, having given so many in a prism, and the Rule for this and that being so like.

Prob. XXXV. *The dimensions of the frustum of a parabolical pyramidoid given, to find the solid content*

Definition. Frustum, is the lower part of a pyramidoid, cut parallel to its base.

A general rule.

This is the same with the General Rule for a prismoid, save only in the third precept, which in this case is thus

As 2..that sum :: length·· solid content required.

But for the frustum of a square parabolical pyramidoid, take this particular rule.

1. To the square of the greatest side, add the square of the least side into one sum; then,

2. Say, as 2,·· that sum :: length ·· solid content required.

And for a Round Frustum, that is parabolical, the rule is;

1. Add the square of each diameter into one sum; then

2. Say, as 2. 546·· that sum :: length ·· solid content.

Or more largly thus; as 2.54649, is to the aforesaid sum; so is the length of the solid content.

Examp. 1. The frustum of a square parabolical pyramidoid, whose

side at top————inches 4
side at bottom————6
perpendicular length————48
What's the solid content? *Answ.* 1824 inches.

For; as 1 ·· 4 :: 4 ·· 16 the square at top
as 1 ·· 6 :: 6 ·· 36 the square at bottom
as 1 ·· 4 :: 6 ·· 24 the product of the two sides.

Sum of the two squares 76 inches, and, the product of the two sides.

Then say; as 2 ·· 76 :: 48 ·· 1824 inches, the solid content.

Exam. 2. The frustum of a round parabolic pyramidoid, (or the Frustum of a parabolic conoid) whose

diameter at bottom————4 }
diameter at bottom————6 } inches
perpendicular length————48 }
What's the solid content? *Answ.* 1433 inches.

For

For; as 1 ·· 4 :: 4 ·· 16 the square at top.
as 1 ·· 6 :: 6 ·· 36 the square at bottom.
as 1 ·· 4 :: 6 ·· 24 the product of both diameters.

Sum of the two squares 76 inches, the product of both diam.
Then say; as 2.546 ·· 76 :: 48 ·· 1433 inches the solid content.

Sect. V. *The application of the whole, in measuring board, glass, plaistering, painting, paving, and land; timber and stone; gauging of cask, and a ship's hold.*

1. BOard or plank, glass, and flat stone, are measured by the Foot Square, or Superficial Feet, containing 144 square inches, or 12 times 12: so that to know how many square feet are contained in the area, or content of any superficies taken in inches, the proportion is this.

As 144 ·· 1 :: content in inches ·· content in feet.

But the easiest way, is to have the foot of 12 inches divided decimally into 100 parts, called foot measure; and by such a foot to take the dimensions of the thing you would measure, or know the content of in feet.

Then consider, if the thing to be measured be a circle, triangle, square, long-square, &c. the rules proper for such a figure (in Sect. 3 of this Chapter) direct to find the area. That is,

If the thing to be measured be a circle, then Prob. 20 or 21 sheweth how to find its area; if it's a triangle, then Prob. 24 gives a rule to find the area; if a parallelogram, Prob. 25 hath a rule to find its area, whether it be a square, a long-square, a rhombus, or rhomboides; now floors and ceilings of houses are generally square or long-squares; also boards, planks and flat stones, (are commonly) squares or long-squares. If a trapezia, then Prob. 26 sheweth how to measure it; if it be an ellipsis, Prob. 27 hath a rule for its measuring; and such are oval tables. And if the thing to be measured be a parabola, then Prob. 28 sheweth how to find its area.

2. Plaistering, painting, and paving, is measured by the yard-square containing nine square feet; and therefore after you have found the content in feet; the proportion is this;

As 9 ·· 1 :: content in feet; content in yards.

3. Timber is measured by the cubic foot, containing 1728 solid inches: and when the content of any solid body is known in cubic inches to reduce them into cubic feet, which is the timber, or stone foot, the proportion is this.

As

As 1728 ·· 1 :: cubical inches ·· solid feet.

But measuring the dimensions of a solid, by the aforesaid decimal feet, the rules proper for it (in Sect. 3. of this Chap.) as a sphere, prism, *&c.* Finds the solid content in feet.

That is, if it be a sphere, then Prob. 29 hath a rule to find its solid content, such are bullets, and granadoes used in great guns, mortars, or bombs.

If a spheroid, then Prob. 30 sheweth the measuring of it, and such are things in shape like an egg, whose ends are equal.

If a Prism, then Prob. 31 directs its measurement, and by it, all strait pieces of timber or stone, whose ends are alike and equal, are measured.

If a Pyramid, then Prob. 32 shews the measuring of it, and such are spire steeples, and all straight solids ending in a point at one end.

If a Prismoid, then Prob. 33 directs its measuring, and such is all taper timber, whether round, or square.

If a Pyramidoid, then Prob. 34 sheweth the measuring of it, and such is the half of all casks, if they were continued, from the bung by the head, till they end in a point.

If a Frustum of a Parabolical Pyramidoid, then Prob. 35 serves to measure it, and such are Close Casks, if cut in halves through the bung, and parallel to each head; so that by this Problem is taught the way of finding the half content of a cask; whose double is the whole solid content. But a more particular rule for gauging a cask, followeth in the next problem.

4. Land is measured by the rod or pole, containing in length, feet 16, and a square rod is feet $272\frac{1}{4}$; an acre of land containeth 160 square rods.

Now the readiest way to cast up the content of land in acres is to take the dimensions by a Four Pole Chain, decimally divided (that is into an 100 links) then the rules (in Sect. 3. of this Chap.) proper to the form of it, (whether a triangle, square, long-square, rhombus, rhomboides, or trapezia) finds the content in the square chains; which are turned into acres thus;

As 10 ·· 1 :: square chains ·· acres.

5. Gauging is by the gallon, and that either Beer containing 282 Cubical Inches, or Wine 231: then to reduce Cubical Inches into gallons of either kind the rule is;

As $\left\{\begin{matrix}282\\231\end{matrix}\right\}$ ·· 1 :: Cubical Inches ·· Gallons of $\left\{\begin{matrix}\text{Beer}\\\text{Wine}\end{matrix}\right.$

So that the dimensions of any Solid Body taken in inches, the proper rules for that body finds its content in inches, and the rule above finds the gallons of Beer or Wine it will hold.

Prob.

Prob. XXXVI. *To gauge a cask, taken, as the middle frustum of a spheroid.*

The Rule, Add twice the square of a bung-diameter, and once the square of the head, into one sum; then say,

2. As 3.82 ·· that Sum :: Length, Solid Content of the cask in inches; and then the gallons of beer or wine are found by the following rule. Or thus,

1. Say, as 1 ·· 0.7 :: Difference of Head and Bung ·· a Fourth Number.

2. That 4th number add to the head diameter the sum is a mean diameter; then say,

As $\left\{\begin{matrix}18.95\\17.15\end{matrix}\right\}$ .. Sq. Mean Diam. :: Length ·· $\left\{\begin{matrix}\text{Beer}\\\text{Wine}\end{matrix}\right\}$ Gallons

Examp. A Cask whose Bung Diameter is Inches 23
Head Diameter———————— Inches 19.9
Length of the Cask ———————Inches 27.4
What's its content in Beer, or Wine Gallons?

Answ. Beer Gallons 36.99, or Wine Gallons 45.5

As 1 ·· 0.7 :: 3.1 ·· 217, which added to 19.9; makes the mean diameter to be 22.07. Then,

As $\left\{\begin{matrix}18.95\\17.15\end{matrix}\right\}$ ·· Square 22.07 :: 27.4 ·· $\left\{\begin{matrix}\text{36.99 Beer}\\\text{45.5 Wine}\end{matrix}\right\}$ Gallons

That is; the extent form the first term to the second, twice turned over from the third, gives the gallons required.

Prob. XXXVII. *To measure a ship; that is, to find her tunnage.*

The rule. 1. Say as 1 ·· Breadth : : Half-Breadth ·· Fourth Number.

2. Then: as 94 ·· 4th Number :: Length ·· Tuns required.

Examp. A ship 75 feet by the keel, and 23 feet by the Beam; what's her tunnage? *Answ.* 211. tuns

For, as 1 ·· 23 :: 11 . 5 ·· 264.5, the 4th number.
Then, as 94 .. 264 . 5 :: 75 .. 211 tuns required.

8. *To measure bales or cases, or to give the tunnage of them; they are prisms, and their dimensions taken by the decimal foot; the content in cubical feet is found by prob.* 31.

And then say,

As 66 ·· 1 :: cubical feet ·· tuns required.
Or thus, as 66 ·· Area Base :: Length ·· tuns required.

Examp.

Examp: A Bale whose { breadth is— — — — —feet 4.2 / depth— — — — — —2.6 / length— — — — — —5.7 }
What's the Content in tuns? *Answ.* 0.943 parts. For,
As 1 · 4.2 :: 2.6 ·· 10.92 Area of its Base. Then,
As 66 ·· 10.92 :: 5.7 ·· tuns, 0.943 parts required.

Note, That 66 feet is the content of a case that incloseth two English Butts, so that this Rule excludes the Cantlings of the Cask, which is better than $\frac{1}{3}$ part; therefore allowing for the Cantlings or Vacancy to be 26 feet, the remaining 40 feet is to be counted for a tun: and then,

The rule is, as 40 ·· Area Base :: length ·· tuns required.
And then the foresaid Bale contains tun 1.556 parts. For,
As 40 ·· Area Base 10.92 :: Length 5.7 ·· tun 1.556 parts.

So much for Geometry; Trigonometry is next in order to be learned.

Chap. II. *Containing the doctrine of plain triangles.*

TRigonometry, is that part of Geometry which treats more particularly about the measuring of triangles, wherein having three things given; either sides, angles, or both; a 4th (side or angle) may be found; and is either Plain or spherical; it's the former we begin with.

Section I. *Of things necessary to be understood, relating to plain trigonometry.*

1. A Triangle is any Three-cornered figure; it consisteth of six things, Three Sides and Three Angles, and is either Plain or Spherical.

2. A plain Triangle is projected on a plain superficies, and therefore its Sides are Right-Lines; but the Sides of a Spheric Triangle, are Arks of the Sphere, of which more in the chapter of Spheric Trigonometry.

3. An Angle is the meeting of any two Lines, making a Corner; and is either a Right-Angle, containing just 90 deg. or Oblique, more than 90 deg. called an Obtuse-angle; or less than 90 deg. called an Acute-angle.

4. When two Lines crossing one another, make the angles on every side equal, then those Angles are Right and the Lines are Perpendicular.

5. A Degree, is the 360th part of the Periphery of any Circle; the 4th part 90 is called a Quadrant, and the half 180 is a Semicircle. Also a Degree containeth 60 Min. and a Min. 60 Seconds, &c. as in Prob. 9. Defin. of Geometry, in Page 15.

6. By Complement of any Degrees, understand what those Degrees want of 90.

7. A Triangle, is either Right-angled, having one Right-angle or Oblique, having no Right-angle.

8. In a Right-angle Triangle, the Side opposite to the Right-angle, is called the Hypotenuse, and the two Sides containing the Right-angle, are called Legs.

9. In all plain Triangles the sum of the three Angles added together are equal to 180 Degrees.

10. The Angles (of a plain Triangle) being only given, the Proportion of the Sides can only be determined; therefore,

11. In a Right-angle Triangle, two things given (if one be a Side) are sufficient to find a Third; but,

12. In Oblique Triangles three things and one of them a Side, must be given to find a fourth.

13. Three Letters signifies an Angle; as BAC signifies the Angle A; and two Letters a Side; as AB signifies the Side AB, &c.

14. Given things, whether Sides or Angles, are marked with a Dash, thus () and required things, with a Cypher thus, (°),

15. $\left\{\begin{array}{l}\text{d.}\\\text{m.}\end{array}\right\}$ after any Number signifies $\left\{\begin{array}{l}\text{Degrees,}\\\text{Minutes,}\end{array}\right\}$ thus 25 d. is 25. Degrees, and 31 m, is 31 Minutes.

S.	stands for	sine
S. c.	stands for	sine complement or co-sine.
T.	stands for	tangent.
T. c.	stands for	tangent complement or co-tang.
Sec.	stands for	secant.
Sec. c.	stands for	secant complement, or co-secant.
co. ar.	stands for	complement arithmetical.
..	stands for	is to, or to the.
::	stands for	so is; as thus, 2..4 :: 3..6.

That is, as 2 is to 4, so is 3 to 6.

16. There are seven cases in Right-angles Triangles, and six in Oblique. Their solution follows; but first of Right-angle Triangles.

Sect. II. *The first axiom, and the seven cases of plain right-angle triangles depending thereon.*

Axiom 1. IN all plain Right-angle Triangles, if one of its sides be made radius, the other two will be either sines, tangents, or secants, that is,

1. If the hypotenuse be radius, each leg is the sine of its opposite angle. See Plate 2. Fig. 1. for the first Axiom.

2. If one leg be radius, the hypotenuse is secant, and the other leg is tangent of the angle opposite to this leg. See Plate 2. Fig. for the first Axiom.

And what proportion the side made radius, hath to radius; the same hath the other sides, to the sines, tangents, secants or by them represented; and the contrary. And,

Note, 1. To find a side, any side may be radius, saying thus; As the word on the side given; is to the side given; So is the word on the side required, to the side required.

Note, 2. To find an angle, one of the given sides must be radius. Then say,

As one given side, is to the word on it.
So is the other given side, to the word on it.

Observe to begin with the side made radius.

These two notes (to the diligent Reader) are sufficient to frame any proportion by the first Axiom, making any side of a Right-angle Triangle the radius.

Problem 1. Case 1. *The angles and hypotenuse given, to find either of the legs.*

Examp. In the right angle triangle ABC Plate 2. Fig. 1.

The $\left\{\begin{array}{l}\text{Hypot. AC 121 leag.}\\ \text{Angle BAC 54d. 30m.}\end{array}\right\}$ given leg. $\left\{\begin{array}{l}\text{AB}\\ \text{BC}\end{array}\right\}$ required.

This triangle is made by Prob. 10. of Geometry.

If you make AC radius, the proportion (by Axiom 1. and *Note* 1.) is thus,

As radius, is to the hypotenuse AC, so is the sine of the angle BAC, to leg BC: or thus briefly.

Radius -- hypot. AC :: S. BAC -- leg. BC.

121 leag. 54d. 30m.

9.910686
2.082785

leag.
11.99347198.51 parts.

To work proportions by logarithms, obſerve this

General Rule. Add the logarithm of the ſecond and third term together, and from that ſum ſubſtract the logarithm of the firſt term, the remainder is the logarithm of the fourth term, or number ſought.

As in the foregoing proportion, the ſum of the logarithms of the ſecond and third terms added together is 11.993471; from which it is eaſy to ſubſtract the logarithm of the firſt term (being radius) by cancelling, cutting off, or leaving out the firſt figure to the left-hand, and then it is 11.993471, which brings forth 98.51 that is, leagues 98. 51 parts of 100 for the leg. BC, the fourth term or ſide required.

By Gunter's Scale *thus*.

Radius ·· AC :: S. BAC ·· BC. That is,

S. 90d. ·· 121 leag. :: S. 54d. 30m. ·· leag. 98.5 tenths.

That is to ſay, the extent from ſine 90d. (on the Line of Sines) to 121 leagues or miles (on the Line of Numbers) will reach from ſine 54d. 30m. (on the ſame Sines) to leagues or miles 98.5 tenths, (on the line of Numbers) for the leg. BC near as above.

Obſerve the like in all that follows, except in thoſe proportions wherein is the word Secant, which is wrought only by the logarithms.

The three ſeveral proportions making each ſide radius, to find the leg. BC, are theſe which follow.

$$\left.\begin{array}{l}\text{Radius .. S. BAC}\\ \text{sec. BAC ·· T. BAC}\\ \text{sec. ACB ·· Radius}\end{array}\right\} :: \text{Hypotenuse AC ·· Leg BC.}$$

Likewiſe to find the Leg AB, they are theſe following.

$$\left.\begin{array}{l}\text{Radius ·· S. ACB}\\ \text{sec. BAC ·· Radius}\\ \text{sec. ACB ·· T. ACB}\end{array}\right\} :: \text{Hypotenuse AC ·· Leg AB.}$$

Note. When Radius is not the firſt Term in the Proportion, then take the Complement-Arithmetical of the Logarithm of the firſt Term; which how to find is ſhewed in Chap. 1. Propoſition 9. Of the uſe of the Table of Logarithms, Sines, Tangents and Secants, this Comp. Arith. or co. ar. add to the Logar. of the ſecond and third Terms, and from the characteriſtic of their ſum ſubſtract 10 or 20, the remaining figures is the Logarithm of the fourth term ſought; as may by ſeen in the following proportion in Problem II.

Prob. II.

Prob. II. Case 2 and 3. *The angles and one leg given; to find the hypotenuse, and the other leg.*

Examp. In the right-angle triangle ABC Plate 2. Fig. 2.

The { Ang. ACB 35d. 30m. / Leg. BC 98 leagues } given : { Hyp. AC / Leg. AB } required.

This Triangle is made by Problem 12 of Geometry.

Make the Hypotenuse AC Radius, and the proportion (by Axiom 1 and Note 1) is thus.

As the Sine of the Angle BAC, is to the Leg BC, so is Radius to the Hypotenuse AC. Or thus;

S.BAC -- Leg BC. :: Radius, -- hypotenuse AC.

45d. 30m. 98. Leg ————————

10.000000
1.991226
co. ar. 0.089314
———————
12.080540 (Leag. $120\frac{4}{10}$

By Gunter's *Scale thus*;

S.BAC -- leg BC :: Radius -- Hypotenuse AC. that is S. 54d 30m. -- 98 Leag. :: S. 90d. -- Leag. 120.4tenths.

That is, the extent from Sine of 54d. 30m. (on the Line of Sines) to 98 Leagues (on the Line of Numbers) will reach from Sine 90d. to Leag. 120.4 tenths the Hypotenuse required.

The three several proportions, making each side radius, to find the hypotenuse, are these following.

S.BAC -- radius
T.BAC -- sec. BAC } :: leg BC -- hypotenuse AC.
Radius -- sec. ACB

And to find the leg AB, they are these;

S.BAC -. S.ACB
T.BAC -- radius } :: leg BC -- leg. AB.
radius -- T.ACB

Note, In working by Gunter, when a tangent is mentioned, the radius then is the tangent of 45d. as in the two last proportions it is,

As T. BAC -- radius :: leg BC. -- leg AB. Which is T 54d. 30m. -- T.45d. :: 98 leg. -- leg. 59.8. tenths.

That is the extent from 54d. 30m. to 45d. (on the Line of Tangents) will reach from 98 leagues, to leagues 69. 8 tenths on the Line of Numbers, for the leg. AB.

As radius -- T.ACB : : leg BC -- leg AB. Which is T. 45d. -- T.35d. 30m. :: 98d. leag. -- leag. 698 tenths,

 That

That is, the extent from T.45d. to T, 35d. 30m. will reach from 98 leagues, to leag. 69.8 tenths, as before.

Prob. III. case 4 and 5. *The hypotenuse and one leg given; to find the angles and the other leg.*

Examp. In the right angle triangle ABC. Plate 2. Fig. 3.

The $\left\{\begin{array}{l}\text{hyp. AC 121}\\ \text{leg AB 69}\end{array}\right\}$ leagues given: $\left\{\begin{array}{l}\text{ACB or BAC}\\ \text{and leg BC}\end{array}\right\}$ req.

This triangle is made by Prob. 11. of Geometry.

1 To find the angles.

If you make the hypotenuse AC radius, the proportion (by Axiom 1. and Note 2.) is thus;

As the hypotenuse AC is to radius; so is the leg AB, to the sine of the angle ACB. Or thus;

Hypot. AC ·· Radius :: Leg AB ·· S.ACB.

121 Leg. ·· S.90d. :: 69 Leag. ·· S.34d. 45m. Which substract from 90d. 00m.

Remainder is angle BAC ——— 55d. 15m. by the 9th of Section 1 of this Chapter in page 35.

And if the leg AB is radius, then the proportion (by Axiom 1. and Note 2.) is thus.

As the leg AB, is to the radius; so is the hypotenuse AC to the secant of the angle BAC. Or thus.

AB 69 leag. ·· radius :: AC 121 leag. ·· sec. BAC 55d. 15m.

Note; This proportion is not wrought on the Gunter because of the word Secant in the 4th term; but being wrought by the Tables (as before directed) will produce the angle BAC 55d. 15.m. as above; which subtracted from 90d. gives 34d. 45m. for the angle ACB, as before.

2. The leg BC may be found by the 1st or 2d case several ways: as thus,

Radius ·· AC :: S.BC
S. ACB ·· AB :: S.BAC
Sec. BAC ·· AC :: T.BAC
Radius ·· AB :: T.BAC
Sec. ACB ·· AC :: radius
T. ACB ·· AB :: radius

} ·· BC leagues 99.4 tenths.

Prob. IV. case 6 and 7. *The legs given; to find the angles and hypotenuse.*

Examp. In the right-angle triangle ABC Plate 2. Fig. 4.

The leg. $\left\{\begin{array}{l}\text{AB 98}\\ \text{BC 69}\end{array}\right\}$ leag. given. $\left\{\begin{array}{l}\text{angle BAC or ACB}\\ \text{\& hypotenuse AC}\end{array}\right\}$ req.

This triangle is made by Prob. 13. of Geometry.

1. Make

1. Make the leg AB radius, and the proportion (by Axiom 1. and Note 2.) is thus;

As the leg AB, is to radius; ſo is the leg BC, to the tangent of the angle BAC. Or thus,

Leg AB ·· leg BC :: radius ·· T.BAC,

98 leag. ·· 69 leag. :: T. 45d. ·· T. 35d. 09m. which

ſubtract from ———— ————90d. 00m.

The remainder is —————54d. 51m. for the angle ACB, by the 9th of Section 1. of this Chapter, in Page 35.

And if the leg BC is made radius, the proportion is thus;

Leg BC ·· leg AB :: radius ·· T.ACB.

69 leag. 98 ·· leag. :: T. 45d. ·· T. 54d. 51m. as before;

Which being ſubtracted from 90, leaveth 35d. 00m. for the angle BAC. Either of theſe proportions is ſufficient to find both angles.

2. The hypotenuſe AC may be found by the 2d caſe ſeveral ways.

Firſt, making the hypotenuſe AC radius; thus,

$\left.\begin{array}{l}\text{S.BAC} \cdot\cdot \text{BC} \\ \text{S.ACB} \cdot\cdot \text{AB}\end{array}\right\}$ :: radius ·· hypotenuſe AC.

Secondly, making the leg AB radius, thus,

$\left.\begin{array}{l}\text{radius} \cdot\cdot \text{AB} \\ \text{T.BAC} \cdot\cdot \text{BC}\end{array}\right\}$ :: ſec. BAC ·· hypotenuſe AC.

Thirdly, making the leg BC radius; thus,

$\left.\begin{array}{l}\text{radius} \cdot\cdot \text{BC} \\ \text{T.ACB} \cdot\cdot \text{AB}\end{array}\right\}$ :: ſec. ACB ·· hypotenuſe AC.

Theſe 6 proportions, if the learner works them, he'll find them all produce leagues 119.8 for the hypotenuſe AC.

Note; The 5th and 7th caſes may be performed by the 47th propoſition of the Firſt Book of Euclid's Elements, which proves the ſquare of the hypotenuſe, is equal to the ſum of the ſquares of the two legs; therefore,

1. By natural arithmetick, extracting the ſquare root; the rules are theſe.

Firſt, In the 5th caſe to find a leg; when the hypotenuſe and one leg is given, thus,

The Square Root of the Difference of the Squares of the hypotenuſe and one Leg, is the other Leg.

Secondly, In the 7th caſe to find the hypotenuſe, when both the legs are given, thus,

The Square Root of the Sum of the Squares of both legs, is the Hypotenuſe.

2. By logarithms in theſe two rules following

Firſt Rule. When the hypotenuſe and one leg is given, to find the other leg, thus,

 Half

Half the sum of the Logarithms, of the sum and difference of the Hypotenuse and given Leg; is the Logarithm of the Leg required.

Second Rule. When both legs are given, to find the hypotenuse, it is thus,

From the double Logarithm of the greater Leg, subtract the Logarithm of the lesser Leg; the absolute number answering to it, add to the lesser Leg; half the sum of the Logarithms of that sum, and lesser leg; is the logarithm of the Hypotenuse required.

Example 1. The Hypotenuse AC 121 leagues, and the leg AB 69 leagues: what is the leg BC by the Square Root?

Hypotenuse AC ———— 121 and Leg AB ——— 69

121	69
121	621
242	414
121

Square of AB is 4761

Square of AC is— — —14641

Square of AB is— — — 4761

Diff. of the Square is— — —9880(99.39 is the Leg BC

81

189)1780

1701

1983)7900

5949

19869)195100

178821

Remainder is — — — —16279

By that the Leg BC is leagues 99.39 parts of 100

By Logarithms thus,

The Hypotenuse AC — — —121 leagues

The given Leg AB — — —69 leagues

Sum of AC and AB — — — 190 its Log. is 2.278754

Difference of AC and AB — —52 its Log. is 1.716003

The sum of the Logarithms is — — — —3.994757

The half sum of these Logarithms is — — —1.997378

Whose absolute number is 99.39; that is, Leagues 99.39 parts of 100 is the leg BC, the same as before.

Example

Example. 2. The Leg AB is 98 miles, and the Leg BC 69 miles given: what is the Hypotenuse AC? By the Square Root.

The Leg AB— —	—98.	And Leg BC— —	—69
	98		69
	784		621
	882		414
Square of AB is————	9604	Square of BC is ———	-4761
Square of BC is ———	4761		
Sum of the Square is	14365(119.8 that is 119 leagues		
	1 $\frac{2}{10}$ is the hypotenuse AC		
	21)43		
	21		
	229(2205		
	2061		
	2388(20400		
	19104		
Remainder is ———	———-1296		

By Logarithms, thus,

The greater Leg AB 98, its Logarithm is— ——	1.991226
Multiply its Logarithm by—— —— ——— ——— ——	---2
The double Logarithm of the leg AB is ——— —— —	3.982452
The lesser leg BC 69 Miles, its Logarithm is————	1.838840
Absolute number 130.2 answering the Logarithm——	2.143603
sum is————-200.2 its Logarithm is—— ——— —	2.318481
the lesser Leg BC 69 Miles, its Logarithm is———	1.838849
the sum of the two last Logarithms is———— ——	4.157330
the half is the Logarithm of AC 119$\frac{8}{10}$ required	2.078665

Section III. *Three other axioms, with the six cases of oblique plain triangles thereunto belonging.*

Axiom 2. IN all plain Triangles, the sides are in such proportion one to another, as are the Sines of their opposite Angles. That is,

1. As

1. As the Sine of any one Angle, is to its opposite side; so is the Sine of any other angle to its opposite Side.

2. As a Side, is to the Sine of its opposite Angle; so is a Side, to the sine of its opposite Angle.

Note; To find a Side, begin with an Angle; but to find an Angle, begin with a Side.

From this Axiom are drawn the proportions for the first, second, and third Cases following.

Prob. V. Case 1. *Of obliquangles. Two angles and one side given; to find either of the other sides.*

Examp. In the oblique triangle BDC. Plate 2. Fig. 5.

The angle {BDC 101d. 25m. / CBD 44d. 42m.} ——BC 76 yards. } given: side {CD and BD} req.

This triangle is made by Prob. 14. of Geometry.

1. The proportion according to the second Axiom for finding CD, is this,

As the sine of the angle BDC, is to the side BC; so is the sine of the angle CBD, to the required side CD. Or thus;

S. BDC ·· side BC :: S. CBD ·· side CD required.

S. 101d. 25m. ·· 76 yards :: S. 44d. 42m. ·· yards. 54.5 tenths.
S. 180d. 00m.

S. 78d. 35m.

Note; The sine of 101d. 25m. is found by subtracting it from 180d. according to Chapter 1. Proposition 8. Of the uses of the Tables of Logarithms, &c.

2. To find the side BD, the proportion is,

S. BDC ·· side BC :: S. BCD ·· side BD.

S. 101d. 25m. 76 yards : : S. 33d. 53m. ·· yds. 43.3 tenths
S. 180d. 00m.

S. 78d. 35m.

Prob. VI. Case 2 and 3. *Of obliquangles.*

Two sides and one angle opposite to one of them given; to find the other opposite angle, and the third side.

Note; The given angle is obtuse, the angle sought is acute.

But when the given angle is acute, and opposite to the lesser given side, then the required angle is doubtful; whether acute or obtuse, and ought to be determined before the operation.

Example.

Example. In the oblique triangle BCD. Plate 2. Fig. 6.

Side {BC 106 / BD 65} yards } given : { angle BDC Obtuse, and the side CD } req.
Angle BCD 31d. 49m.

This triangle is made by Prob. 15 of Geometry.

1. For the angle BDC the proportion is,

As the side BD, is to the sine of the angle BCD : so is the side BC, to the sine of the required angle BDC. Or thus, side BD ·· S. BCD :: side BC ·· S. BDC.

65 yards ·· S. 31d. 49m. :: 106 yards ·· S. 59d. 17m. which subtract from——————180d 00m.

remainder is the angle BCD--120d. 43m.

Note ; The proportion produceth 59d. 17m. for the required angle : but being its obtuse, you must take its supplement to 180d. *viz.* 120d. 43m. as above.

2. Find the third angle by the 9th of Section 1. of this Chapter, in Page 35, then you may find CD by the first Case.

This Case hath been omitted by most, the reason (I suppose) is the doubtfulness of the required angle ; but if determined (before) to be either acute or obtuse, the third side is limited, and then may be a Case as well as any other. And the proportion may be

S. BCD ·· side BD :: S. CBD ·· side CD.

S. 31d. 49m. ·· 65 yards. :: S. 27d. 28m. ·· yds. 56.8 tenths.

Or,

S. BDC ·· side BC :: S. CBD ·· side CD.

S. 120d. 43m... 106 yds. :: S. 27d. 28m. ·· yds. 56.8 tenths as before.

Axiom 3. IN all plain Triangles ; as the sum of two sides, is to their difference, so is the tangent of the half sum of their two opposite angles, to the tangent of the half difference of the two unknown angles.

Add the half difference of the angles to their half sum, finds the greatest angle ; and subtract the half difference from the half sum, finds the lesser angle.

Prob. VII. Case 4 and 5. *Two sides, and their contained angle given ; to find either of the other angles, and the third side.*

Examp. In the oblique triangle BCD, Plate 2. Fig. 7.

Side {BC 109 / BD 76} leag. } given : } angle { BDC or BCD and side CD } req.
angle CBD 101d. 30m.

This triangle is made by Prob. 16. of Geometry.

1. For

1. For the angles BCD, and BDC, the operation is

Side { BC 109	The three angles— — — — —180d. 00m.	
Side { BD 76	Subtract the given angle CBD — 101d. 30m.	
Sum of sides 185	The two opposite Angles { Sum is 78d. 30m.	
Their differ. 33	The two opposite Angles { Sum is 39d. 15m.	

Then, as the Sum of the Sides BC and BD, is to their Difference, so is the Tangent of half the sum of the Angles BCD and BDC, to the Tangent of half their difference. Or thus,

Sum BC&BD ·· Diff. BC&BD :: T. ½ Sum Angles ·· T. ½ diff.

185 Leagues ·· 33 Leagues :: T. 39d. 15m. ·· T. 18d. 17m.

The half diff. of the angles - - - 8d. 17m.

Added is the greater angle———47d. 32m. BDC } required.
Subtracted is the lesser angle———30d. 58m. BCD }

2. The proportion for the side CD (by the first Case of oblique triangles) may be this:

S. BCD ·· side BD :: S. CBD ·· side CD.

S. 30d. 58m. ·· 76 leag. :: S. 101d. 30m. ·· leag. 144. 5 tenths.

Axiom 4. FRom the half sum of the three Sides, subtract each Side (but first that Side opposite to the Angle required, then the rest) severally, noting their remainders. Then,

As the product of the half Sum of the Sides, and first remainder is to the product of the other two remainders; so is the square of Radius to the square of the Tangent of half the Angle opposite to that first remainder.

Prob. VIII. Case 6. *Three sides given to find an angle.*

Example. In the triangle BCD. Plate 2. Fig. 8

The Side { BC 105, BD 85, CD 50 } feet given: angle { BDC, BCD, CBD } required.

This triangle is made by Prob. 17. of Geometry.

The operation for the angle CBD is

Side { BC	105	The half sum Leag. 120. co. ar.		7.920819
Side { BD	85	The first Remainder 70. co. ar.		8.154902
Side { CD	50	The other 2 Remain. { 35. logar.		1.544068
Sum of Sides	240	The other 2 Remain. { 15. logar.		1.176091
½ their sum	120		sum	18.795880
From ½ sum	} 70	tangent 14d. 02m—	½ sum	9.397940
Subt. each side	} 35	doubled 14d. 02m.		
there remains	} 15	Produceth 28d. 04m. for CBD required.		

This Axiom finds an angle at one operation, yet not being applicable to the instrumental way of working proportions, you

you have this fourth Axiom in other terms; which finds an angle at two proportions, and may be wrought both instrumental and logarithmetical.

Axiom. 4. Useful, when three sides of a triangle are given; to find an angle.

As the longest side, is to the sum of the two shortest; so is the difference of the two shortest, to the difference of the segment of the base or longest side.

Note; Let fall a Perpendicular (from the Angle opposite) to the longest Side, which divideth it into two Segments; and the Oblique-Triangle into two Right-Angle-Triangles.

As in the aforesaid triangle BCD. Plate 2. Fig. 8.

Let fall the Perpendicular DA, which makes the Segments of the Base to be BA, and AC, and the two Right-Angle-Triangles BAD, and CAD, and the difference of the segments BE

1. To find BC the difference of the segments of the base.

Shortest sides —————— { BD— ———— 85 feet
{ CD—————— 50 feet

Added, is the sum of the two shortest sides———— 135 feet

Subtracted is their difference———————— 35 feet

Then as the side BC, is to the sum of BD and CD; so is the difference of BD and CD, to BE the difference of the segment BA and AC. Or thus,

Side BC ·· Sum BD & CD :: Diff. BD & CD ·· BE the Diff. of seg. 105 feet ·· 135 :: 35 feet 45 ·· feet

The side BC 105 feet,

Diff. Segment BE 45 feet

Added is————150 { the half is { 75 BA the greater } Segment.
Subtracted is—— 60 { { 30 AC the lesser }

2. The angles BCD or CBD, may be found by the 4th Case of Right-angle-Triangles; thus,

Hypot. BD ·· Radius :: Leg AB ·· S. ADB.
85 Feet ·· S. 90d. :: 75 Feet ·· S. 61d. 54m.
Which subtracted from————90d 00m.
Remainder is the angle CBD 28d. 06m. as before.

Thus much for Plain Triangles; and to compleat Trigonometry, Spherical should be next. But I count the application of this before the Doctrine of that, most conducible to the Learners Proficiency: therefore will descend to the necessary uses of Plain Trigonometry in Plain and Mercator's sailing, which will make way for Spherical Trigonometry.

CHAP.

CHAP. III. *Plain trigonometry applied in problems of sailing by the plain* sea-chart, *commonly called* plain-sailing.

AND that nothing may be wanting to the accomplishment of Navigation, I will begin with the Julian Calendar, and thenthe use of the Plain-Chart, before I apply Plain-Trigonometry to Plain-Sailing.

Section I. The common note of the Julian Calendar; to find the Prime, Epact, Dominical-Letter, Easter-Day, the Moon's Age, Southing, and time of High-water.

Prob. I. *To find the golden number, cycle of the sun, and* Roman *indiction.*

Definitions. 1. THE Golden Number, or Prime, is a circular revolution of 19 years; in which space of time (it has been supposed) the sun and moon finish all their variety of aspects.

2. The Cycle, or Circle of the Sun, maketh its revolution in 28 years; in which time all the variety of Dominical Letters, and Leap-Years expire, and the 29th year the circle begins again; which number serves to find the Dominical Letter for any year, past, present, or to come.

3. Roman Indiction consisteth of 15 years: for once in 15 years the nations were to pay tribute to the Romans; a thing now out of use with us.

The rule out of Mr. Street'*s memorial verses on the ecclesiastical and civil calendar.*

When 1, 9, 3, to the year hath added been.
Divide by 19, 28, 15.

Examp. I would know the Golden Number, Cycle of the Sun and Roman Indiction for the year 1748, being Bissextile or Leap-Year.

The operation.

The year	1748	1748	1748
Added	1	9	3
Sum is	1749	1757	1751
	19)——(92	28)——62(	15)——(116
	39	77	101
	(1)	(21)	(11)

For the year 1748	golden number	is	1
	cycle of the sun		21
	Roman indiction		11

Prob.

Prob. II. *To find the epact for any year.*

Definition. The epact is 11 days, the year of the Moon lacketh of the Sun's year: the Lunar being 354 days, and the Solar-Year 365 days.

Note; The epact never exceedeth 29, and alters every year 11, and is used to find the Moon's Age and Easter-Day.

Also, *Note*, the Prime changeth the first of January, but the Epact the first of March. The Rule is,

1. Find the Golden Number by Prob. 1.
2. Divide the Golden Number by 3, and note the remainder.
3. Multiply the remainder by 10, and note the product.
4. To that product add the Golden Number; the sum (if it exceeds not 30) is the epact; but if it doth, subtract 30 therefrom, and the remainder is the epact.

Examp. For the year 1748: I demand the epact, the golden number as before found? *viz.* to 1748.

Add — — — — — — 1

19)1749(92
171
39
38
1

Golden Number for 1748, which divide by 3; for each one left add 10; 30 reject: the prime makes epact then.

As no division can be made here to the Golden Number 1
Add — — — — — 10
The Sum then is the epact — — — 11

For the year of our Lord 1748, being Leap-Year.

Prob. III. *To find when it shall be leap-year.*

Definition. Leap-Year is every fourth year, and so called from its leaping a day more that year than in a common year; for in the common year any fixed day of a month changeth successively the day of the week; but in the Leap-Year, it skips or leaps over one day.

Note, The common Year hath 365 days in it, but Leap-Year 366, and then February hath 29 days, which in common Years hath but 28 days.

Example. The year 1748, Quere, is it Common or Leap-Year?

4)1748(437
16
14
12
28
28
0 remains

Therefore

Therefore 1748, is Biſſextile or Leap-Year.

The Rule. Divide the year by 4, what's left ſhall be,
For Leap-Year 0, for paſt 1, 2, or 3.

Prob. IV. *To find the Dominical letter for any year.*

A 1, B 2, C 3, D 4, E 5, F 6, G 7,

Definition 1. The week days in Calendars or Almanacks are expreſſed by the firſt ſeven letters of the alphabet, and one of them is a dominical letter.

2. Dominical Letter, or Lord's Day Letter, is that which ſtands for it, commonly called Sunday.

The Rule. Divide the year, its 4th, and 4 by 7;
What's left ſubtract from 7; the letters given.

Note 1. When its Leap-Year there are two Dominical-Letters; one ſerves to the 25th of February, the other from thence to the year's end.

2. The Dominical-Letter goeth backward in a Common-Year one letter, but in Leap-Year two letters.

3. The Leap-Year having two Dominical-Letters, its the latter of them that this rule finds.

Examp. For the year 1748; I demand the Dominical-Letter

The operation.

The year (by Prob. 3.) is a Leap Year — —	1748
Its $\frac{1}{4}$ part is — — — — — —	437
To it add — — — — —	4
The ſum is — — — —	2189

7)2189)312 quotient, and remainder is 5; which 5
21 ſubtract from 7, remains 2 for the domi-
5) nical letter, which is, B; but the year 1748 being leap year hath two letters which the other foregoing is C. from the 1ſt. of January. to the 1ſt. of March, C takes place in the Leap-Year.

Prob. V. *By the* 19 *epacts, to find Eaſter-limit from the beginning of* March *incluſively.*

Anno. 1748. The Epact being 11, I ſubtract it from 47. the remainder 36. is Eaſter-Limit *Anno*. 1748. that is April the 5th, reckoned from the beginning of March incluſively, the Sunday following is Eaſter-day. But when the Epact is 28 or 29, it muſt be ſubtracted from 77, that ſo the limit may remain. And the next following Sunday after the limit is always Eaſter-Sunday. Therefore Sunday the 10th of April, is Eaſter-Sunday.

Example.

Example. I demand Easter-Limit, by the epact for the year 1748.

The operation.

Epact — — 11
Which subtracted from—47

The remainder 36 is Easter-Limit from the 1st of March, which is, the 5th day of April for the year 1748.

Prob. VI. *To find* Easter-day *for any year.*

Definition. Easter-Day, is next Sunday after Easter-Limit, or the 14th day of the Paschal New-Moon.

Note, Easter-Day is not less than 22 days, nor more than 56 days from the 1st of March.

The rule, 1. Find the Dominical Letter by Prob. 4.
2. And Easter-Limit by the last problem.
3. The letter more by 4 from limit take;
What's left from nearest 7 shall Easter make.

Examp. For the year 1748, I demand Easter-Day?

The operation.

Dominical letter (by Prob. 4 is CB) or B —	2
To it add — — — —	4
The sum is — — —	6
Which subtract from Easter-Limit (found by Prob 5.)	36
Remainder is — — —	30
Which subtract from nearest 7 s — —	35
Remainder is — — —	5
Which added to Easter-Limit, — —	36
That is 41 days from the 1st of March,	41
from which deducting — — —	31

Days, leaves Easter-Sunday anno 1748, on April the 10th.

Prob. VII. *To find the moon's age.*

Definition. The moon's age is how many days are past since the day of her change, which age never exceeds 30 days.

The rule, 1. Find the epact by Prob. 2.

2. To the epact add the day of the month, and the number of the month; the sum if it exceeds not 30, is her age, but if it doth, subtract 30 so oft as you can, and the remainder is her age.

Note, The number of the months are these

January,	February,	March,	April,	May,	June,
0,	2,	1,	2,	3,	4,

July,	August,	September,	October,	November,	December,
5,	6,	8,	8,	10,	10,

Examp. The 20th of May 1748, I demand the moon's age?

The operation.

The epact (by Prob. 2.) for the year 1748 is —	11
Month of the year August — —	6
The day of the month August — —	22
The sum is — — — —	39 days
Which being more than 30 by — —	9 days

is the moon's age required.

Prob. VIII. *To find the moon's southing.*

Definition. The Moon's Southing, is the time of her coming to or upon the meridian; which from the New Moon to her full, is after noon, but from the full to the change, is before noon.

The Rule, 1. Find the moon's age by the last Problem.

2. Multiply her age by 4, and divide the product by 5; the quotient is hours, and the remainder is so many times 12 minutes of an hour, and both is her southing.

Example. The 22d of August, 1748; I demand the moon's southing.

The operation.

The moon's age as before is — —	9 days
Multiply by — — —	4
The product is — — —	36

Which divided by 5, the quotient is 7 hours, and the remainder is one, which makes 12 minutes; so that the moon's southing is 7 hours, and 12 minutes, afternoon being then in her increase.

Prob. IX. *To find the time of full sea, or high-water at any place.*

The rule, 1. Find the moons southing by the last Problem.

2. To

2. To the southing, add the point of the compass making full-sea, (on the full and change day) for the place proposed; the sum is the time of full-sea, or high-water.

Note, The point of the compass making full-sea on the full and change day, may be found in the Tide-table in the Mariners Calendar.

Example. The 20th of August 1748; I demand the time of High-water at London?

The *Operation*. The moon's southings (by Prob. 8.) for the 22d of August. 1748, ——— ——— 7h. 12m. afternoon.
To it add London S.W. and N.E— 3h. 00m.

The sum is the time of high-water 10h. 12m. afternoon.

Sect. II. *The use of the* plain-chart, *or* plot.

IT's requisite to understand the Plain-Chart before the cases of Plain-Sailing; for that contributes much to the understanding this: and for the better understanding of it, mind those following.

Definition 1. The Plain-Chart supposeth the earth and sea to make one flat Superficies, or long Square; in which the meridians are parallel, and the degrees of latitude and longitude, equal in all places; which is only true in the equator.

2. The Equator, is a line drawn east and west, and is 90 degrees distant from each pole: from it latitude beginneth and in it longitude is counted.

3. The Poles are two opposite points, one called the north pole, the other the south pole; and lie north and south from each other; at them is the greatest latitude 90 degrees.

4. The Meridians, are lines (in this chart) parallel to each other; and perpendicular to the equinoctial, and lie north and south; on which are counted the degrees of latitude.

5. Parallels of Latitude, are lines parallel to the equator, and lie east and west.

6. Latitude, is the breadth or distance of any parallel of latitude from the equator; from whence its counted both ways to each pole, ending in 90 degrees, the greatest latitude.

7. North Latitude, is on that side of the equator towards the north pole, and south latitude towards the south pole.

8. Difference of Latitude, is the breadth or nearest distance of any two parallels of latitude; and sheweth how far one place lies to the northward, or southward of the other, it never exceedeth 180 degrees.

9. Longitude (in the Plain Chart) is reckoned on any parallel of latitude, and encreasing to the eastward till it end in 360 degrees the greatest longitude.

10. Difference of Longitude, Meridional Distance, Departure from the Meridian, signify (in the Plain Chart) one and the same thing, and is the nearest distance of any two meridians; it sheweth how far one place is to the eastward or westward of another.

The use of the plain chart.

Problem 1. *To find the latitude of any place in the* chart.

Rule 1. Take the nearest distance of the place to any parallel, or east, and west line.

2. Lay the distance on the graduated meridian, setting one foot of the compasses in the said parallel, and turning the other foot the same way, the proposed place lieth from it; the last sheweth the latitude required.

Example. What latitude doth the Lizard in England lie in?

1. Take the nearest distance from the Lizard to any parallel or east and west line.

2. Lay that distance (on the graduated meridian) from the said parallel, and the moveable foot sheweth 50 degrees the latitude of the Lizard; and it is north latitude, because northward of the equator: do so for any other place.

Prob. 2. *To find the course or bearing of one place from another.*

The rule is thus.

1. Lay a rule on the two places given; and take the nearest distance from the center of any compass to the ruler's edge.

2. Slide the compasses, (being at that distance) with one foot close to the ruler, and the other foot perpendicular to it; in so doing the perpendicular foot points out (among the romb-lines) the course or bearing of the proposed places from one another.

Example. I demand the course from the Lizard in England, to the island Barbadoes.

1. Laying a ruler's edge on the Lizard and Barbadoes, take the nearest distance from the center of a compass to the edge of the ruler.

2. Slide the compasses along by the ruler, keeping one foot perpendicular to it, and it sheweth among the rombs

the courſe to be SW. ½ W. neareſt, from the Lizard to the iſland Barbadoes, the oppoſite point (*viz*. N.E. ½ E. is the courſe from the iſland of Barbadoes to the Lizard.

Prob. 3. *To find the diſtance of one place from another.*

The rule. Extend the compaſſes from one place to another. Meaſure that diſtance on a ſcale of leagues, or on the graduated meridian; the firſt ſheweth the diſtance in leagues; the latter in degrees. This is ſo eaſy, it needs no example.

Problem 1. *To find the meridional diſtance, or departure between any two places in the* chart.

The rule 4. Take the neareſt diſtance from one of the given places, to any meridian.

2. The compaſſes being kept at that diſtance, move them perpendicular along that meridian, till you bring both feet of the compaſſes into the parallel of the other place, there ſtay the compaſſes.

3. The diſtance from the perpendicular foot to the other propoſed place, being meaſured on the graduated meridian, or on the Scale of Leagues giveth the Meridional Diſtance required.

Examp. I demand the meridional diſtance between the Lizard and Cape Finiſterre?

1. Take the neareſt diſtance from the Lizard to a meridional and ſlide the compaſſes with one foot on it, and the other perpendicular, till both feet come to the parallel of Cape Finiſterre.

2. Then the diſtance from the perpendicular foot, to Cape Finiſterre, being meaſured on the meridian, is 3 degrees, 18 minutes, or 66 leagues is the meridional diſtance, and ſheweth Cape Finiſterre is 66 leagues to the weſtward of the meridian of the Lizard.

Prob. 5. *The latitude a ſhip is in, and her meridional diſtance given; to find in the chart where the ſhip is.*

The rule. Lay off the meridional diſtance (according to its nature, whether to the eaſtward or weſtward) from the place it's counted from; and then the neareſt diſtance, from that to any meridian, muſt be kept in one pair of compaſſes.

2. With another pair of compaſſes take the neareſt diſtance of the latitude from any parallel, or eaſt and weſt line.

3. Then move both pair of compaſſes perpendicular, one on the meridian, the other on the parallel, 'till both perpendicular feet meet, and there is the place in the Chart repreſenting the place required.

Sect. III. *Plain trigonometry applied in* plain-sailing.

Definitions. 1. NAvigation, is the guiding or directing a ſhip (through the ocean) from one place to another; it's divided into two generals; domeſtick and remote.

2. Domeſtick or home navigation, is coaſting or ſailing along ſhore; in which the Mariners Compaſs, and Lead, are the chief inſtruments.

3. Romote (which more properly bears the name of navigation) is the conducting a ſhip to any port, and the finding what latitude or longitude ſhe is in at any time; in the practice of which, the Mariners have theſe helps, the Compaſs, the Log, and the latitude.

4. The Compaſs is a circle divided into 4 quadrants, quarters, or principal points; eaſt, weſt, north, and ſouth each quarter into 8 equal parts, being in all 32 rhombs or points, as in Figure 16. of Plate 2. So that ſteering by the compaſs (well made and duly rectified) is known how, or which way the ſhip ſail to a ſmall matter.

5. The Log-Line (truly marked, or ſome other good way) is the inſtrument whereby the Mariners meaſure the ſhip's diſtance ſailed, in Minutes, Miles, or leagues, every hour, watch or day.

Note, Each knot in the Log-Line ought to be 50 feet from each other, and not 42 feet or 7 fathom; an error too frequent among the Engliſh Navigators, and long ſince refuted by Mr. Norwood, in his Seaman's practice.

Alſo the Half Minute Glaſs, uſed with the Log-Line, ought to be truly 30 ſeconds of time, and not 25 or 26 ſeconds, as too many which are ſo called.

6. The Third Help, is the knowledge of the latitude from whence he ſails, to which he is bound, and where the ſhip is at any time; this is attended by Cæleſtial Obſervation (at ſea with a Quadrant or Foreſtaff) taking the ſun or ſtar's meridional altitude.

Now by any two of theſe three things exactly known, the Navigator comes to know at any time, where he is, how far he hath run, and how far he is yet to run, which way or upon what point of the compaſs he is to ſteer; and all this by Trigonometry, in three kinds, *viz.*

Plain

Plain-Sailing, Wright's-Sailing, and Circle-Sailing; as ſhall be ſhewed in order; and firſt of Plain-Sailing, in which take theſe Five general Rules following.

Rule, 1. That 20 leagues being equal to 60 miles or minutes, is alſo equal to one degree of latitude.

But *Note*, One of theſe miles or minutes containeth 6000 feet, and its greater than a Statute or common mile, which is but 5000 feet; of which about 69$\frac{1}{2}$ miles make a degree; whereas in the practice of Navigation, 60 are counted to a degree on the meridian, or any great circle.

2. *General rule*, To find the difference of latitude, when the latitudes of two places are given.

The latitudes $\left\{\begin{matrix}\text{both}\\\text{one}\end{matrix}\right\}$ North $\left\{\begin{matrix}\text{or both}\\\text{the other}\end{matrix}\right\}$ ſouth $\left\{\begin{matrix}\text{ſubtract}\\\text{add}\end{matrix}\right\}$ finds the difference of latitude.

3. *General rule*, To find the latitude the ſhip is in, when the latitude ſailed from, and the difference of latitude is given; for this are the two following caſes.

Caſe I.

In $\left\{\begin{matrix}\text{North}\\\text{South}\end{matrix}\right\}$ latit. ſailing to the $\left\{\begin{matrix}\text{North}\\\text{South}\end{matrix}\right\}$ ward the Latitude increaſeth, add.

Caſe II.

In $\left\{\begin{matrix}\text{North}\\\text{South}\end{matrix}\right\}$ latitude, ſailing to the $\left\{\begin{matrix}\text{South}\\\text{North}\end{matrix}\right\}$ ward the latitude decreaſeth, ſubtract.

And here *Note*, When the latitude decreaſeth, and the difference of latitude is greater than the latitude ſailed from, the ſhip hath croſſed the equator, and changed her latitude; either from north into ſouth, or ſouth into north.

4. *General rule*, The ſum of the three angles of every plain triangle, is equal to 16 points of the compaſs; for

$$\left.\begin{matrix}\text{1 Point}\\ \left.\begin{matrix}8\\16\\32\end{matrix}\right\}\text{points}\end{matrix}\right\}\text{of the compaſs equal to}\left\{\begin{matrix}\text{11d. 15m.}\\ \left.\begin{matrix}90\\180\\360\end{matrix}\right\}\text{degrees.}\end{matrix}\right.$$

5. *General rule*. If a ſhip ſails eaſt or weſt, ſhe keeps in the ſame latitude; and if a ſhip ſails north or ſouth, ſhe keeps in the ſame longitude.

Note, Plain-Sailing is divided into three parts, *viz.*

1. In a Right-Angle Triangle, relating to a ſingle courſe, in which are ſix Caſes.

2. In

2. In a Right-Angle Triangle, relating to ſeveral courſes called a Traverſe.

3. In an Oblique Triangle, in which are but four caſes, tho' multitude of various queſtions.

The Firſt Part of Plain Sailing is contained in the ſix Problems or Caſes following

Prob. *or* Caſe 1. *Courſe and diſtance ſailed given; to find the difference of latitude and the departure from the meridian.*

Example. Admit a ſhip runs 496 minutes SW by W. from the Lizard in 50d. 00m. north latitude: I demand the latitude ſhe is in, and how far ſhe is departed from the meridian?

Obſerve, That in all Problems of Navigation, make the upper end of the book or ſlate to be the north; then the right-hand is the eaſt, and the left-hand the weſt, and the lower end is the ſouth, then,

To delineate the Problem *by the* Plain-Scale.

1. Draw the meridian AB (Plate 2. Fig. 9.) towards the right-hand, when the courſe is weſterly, but when eaſterly towards the left-hand; and put A at the upper end when the courſe is ſoutherly, but at the lower end when its northerly.

2. With a chord of 60 degrees and one foot on A, deſcribe an arch; on that arch lay 5 rhombs (becauſe SW by W is 5 points from the ſouth) taken from the ſcale of rombs, and by it draw a line AC.

3. From any Scale of equal Parts, take the diſtance run 496 minutes, and lay it from A to C; then A repreſents the place ſailed from, C the place the ſhip is come to.

4. From C let fall the perpendicular CB, to cut the meridian in B, and its done. Then, meaſure AB and BC on the ſame Scale of equal Parts, that AC was taken from, will ſhew how much the difference of latitude, and departure from the meridian is, by the Plain Scale.

Theſe directions, with the following explination, being well conſidered, will ſhew how to delineate and anſwer any of the ſix Caſes of Plain Sailing by the Plain Scale: therefore I omit the delineations in the five following caſes; having given ſufficient directions to make any rectangle plain-triangle in Prob. 10, 11, 12 and 13 of Practical Geometry, and ſuch are all the caſes in this part of Plain Sailing.

This

This right angle triangle ABC (Plate 2. Fig. 9.) may be made by Prob. 10. of Gometry; in which Note,

1. The hypotenuse AC (represents the point of the compass the ship steered, and) the ship's distance run.
2. The leg AB, (the meridian) that is the north or south point of the compass the difference of latitude.
3. The leg BC (the east and west point of the compass and a parallel of latitude) the departure from the meridian.
4. The angle BAC (the angle) of the ship's course.
5. The angle ACB (the angle of) the complement of the ship's course.

Note, The angle that the point of the compass steered by (or upon) maketh with the meridian, or north, and south point of the compass, is called the Angle of the Ship's Course, and the angle it maketh with the east, or west point, is the complement of the course.

The course in this Example being SW by W. is 5 points from the south or meridian, and makes 56d. 15m. The Complement of the Course is 3 points; that is 33d. 45m. as may be seen in the table, intituled, A Table of the Angles which every Romb (or Point of the Compass) maketh with the Meridian, at the end of this book.

The things thus explained, the proportion by Chapter 2. Section 2. Axiom 1. and Case 1. of Plain Right Angle-Triangles may be as follows.

For the difference of latitude, three ways, thus;

$$\left.\begin{matrix}\text{Radius}\\ \text{Sec. course}\\ \text{Sec.c.course}\end{matrix}\right\} \cdot\cdot \text{ distance} :: \left\{\begin{matrix}\text{S. c. course}\\ \text{Radius}\\ \text{T. c. course}\end{matrix}\right\} \cdot\cdot \text{ diff. lat.}$$

All these three proportions may be wrought by the logarithms, but I only work the first.

By Gunter'*s Scale, thus,*

Radius ·· distance :: s. c. course ·· difference latitude s. 8. points ·· 496 min. :: s. 3 points ·· min. 275.6 tenths.

Latitude sailed from is — — — 50d. 00m. north.
The diff. of latitude min. 275.6 or — 04d. 36m.

Subtract, giveth latitude the ship is in 45d. 24m. north.

For the departure, three ways, thus;

$$\left.\begin{matrix}\text{Radius}\\ \text{Sec. course}\\ \text{Sec. c. course}\end{matrix}\right\} \cdot\cdot \text{ distance} :: \left\{\begin{matrix}\text{S course}\\ \text{T. course}\\ \text{Radius}\end{matrix}\right\} \text{ departure.}$$

The

The first of these by Gunter's *Scale, thus*;

Radius ·· distance :: S. course ·· depart. from the meridian. S. 8 points ·· 496 min. :: S. 5 points. ·· minutes 412.4 tenths.

So that the departure from the meridian is minutes 412.4 tenths, which makes 6d. 52m. meridian distance west.

Problem *or* Case 2. *Course and difference of latitude given; to find the distance run, and the departure from the meridian.*

Example. If a ship runneth SE by E. from 1d. 45m. north latitude, and then by observation is in 2d. 50m. south latitude, what is her distance and departure? Plate 2. Fig. 10.

This triangle ABC may be made by Prob. 12. of Geometry.

In this *Example*, having latitude the ship sailed from, and latitude she is in by observation, there are the latitudes of two places given, and by the Second General rule, in Page 58, the difference of latitude is found as followeth.

Latitude sailed from	—	—	—	1d. 45m. north.
Latitude by observation is	—	—	—	2d. 50m. south.
The difference of latitude is	—	—		4d. 35m. or 275

minutes; found by multiplying by 60, the minutes in a degree.

1st, For the distance, the proportion may be thus;

S. c. course ·· diff. lat. :: radius ·· distance.

S. 3 points ·· 275 min. :: S. 8 points. ·· 495 minutes.

2. For the departure, thus;

S. c. course ·· diff. lat. :: S. course ·· departure.

S. 3 points ·· 275 min. :: S. 5 points ·· 412 minutes: or 6d. 52m. easting; that is, the ship is so much to the eastward of the meridian of the place she sailed from.

Problem or Case 3. *Course and departure from the meridian given; to find the distance and difference of latitude.*

Example. If a ship sails NE by E. for a port in 3d. 15m. south latitude, until she depart her first meridian 412 min. I demand her distance, and what latitude she is in? Plate 2. Fig. 11.

This triangle may be made by Prob. 12. of Geometry.

1st. For the distance, the proportion may be this.

S. course ·· departure :: radius ·· distance run.

S. 5 points ·· 412 min. :: S. 8 points ·· min. 495.5 tenths.

2d. For the difference of latitude thus;

S. course ·· departure :: Sc course ·· diff. latitude.

S. 5 points ·· 412 min. :: S. 3 points ·· 275 minutes, which being

being reduced is 4 degrees 35 minutes northing, by which find the latitude the ship is in, as here under.

Latitude sailed from is	— — —	3d. 15m. south
Difference of latitude is 275 min. or	—	4d. 35m. north
Subtract, giveth latitude the ship is in		1d. 20m. north

Prob. or Case 4. *Distance, and difference of latitude given; to find the course and departure.*

Example. Suppose a ship sails 496 min. between the south and the west, from a point in 2d. 48m. south latitude, and then by observation is in 7d. 23m. south latitude: what course hath she steered, and what departure hath she made? Plate 2. Fig. 12. This triangle may be made by Prob. 11 of Geometry.

By the two latitudes mentioned in this Example, find the difference of latitude, as followeth,

Latitude sailed from is	————————	2d. 48m. south
Latitude by observation, is	————	7d. 23m. south
Subtract, gives the diff. of lat.	———	4d. 35m. or 275m.

1st, *For the course, the proportion is,*

Distance ·· radius :: diff. lat. ·· Sc. course.

496 min. ·· S. 90d. :: 275 min. ·· S. 33d. 40m.

Which subtract from 90d. the remainder 56d. 20m. is the course, which makes 5 points nearest; or SW by W. for the ship's course.

2d, *The proportion for the departure is,*

Radius ·· distance :: S course ·· departure.

S. 90d. ·· 496 min. :: S. 56d. 20m. ·· 412 minutes.

Prob. or Case 5. *Distance and departure given; to find the course and difference of latitude.*

Example. Admit a ship sails 496 minutes between the north and the west, from the island of Bermudas, in latitude 32d. 30m. north, until her departure is 412 minutes; what course hath she steered? and what latitude is she in? Plate 2. Fig. 13. This triangle may be made by Prob. 11. of Geometry.

1st, *For the course take this proportion.*

Distance ·· radius :: departure ·· Sc. course.

496 min. ·· S. 90d. :: 412 min. S. ·· 56d. 10m. N. westerly.

That is 5 points, which makes the course to be NW by W.

2d, *For the difference of latitude.*

Radius ·· distance :: S. course ·· difference of latitude S. 90d. ·· 496 min. :: S. 33d. 40m. ·· 275 min. or 4d. 35m.

Latitude

	d.	m.	
Latitude ſailed from——— ——— ——— ———	32 :	30	north
Difference of latitude 275 minutes, or	4 :	35	
Latitude ſhip is in——— ——— ——— ———	37 ;	05	north

Prob. or Caſe 6. *Difference of latitude and departure given ; to find the courſe and diſtance.*

Example. If a ſhip's ſouthings be 275 minutes, and her eaſting 412 minutes, what is her courſe and diſtance ? Plate 2. Fig. 14. This triangle may be made by Prob. 13. of Geometry.

1ſt, For the courſe take this proportion.

Diff. lat. .. departure :: radius .. T. courſe

275 min. .. 412 min. :: T. 45d. .. T. 56d. 17m. ſoutheaſterly, or 5 points, which makes the courſe to be SE by E. neareſt.

2d, For the diſtance this proportion.

S. courſe .. departure :: radius .. diſtance.

S. 56d. 17m. .. 412 min. :: S. 90d. .. 495 min.

Theſe ſix preceding Problems are the common caſe of Plain Sailing; which the learner ought to be well acquainted with ; and for that end I here add ſix more for practice, whoſe anſwers may be found by the foregoing rules ;

Queſt. 1. A Ship in 2d. 10m. South Latitude ſails N. by E. 89 Leagues : What Latitude is ſhe in ? and what is her departure ?

Anſw. Latitude 2d. 12m. north, and departure leagues 17 and 35 parts of a hundred.

Queſt. 2. A Ship ſailing SSW from a Port in 41d. 30m. north Latitude; and then by obſervation, the Ship is in 36d. 57m. north Latitude : I demand the diſtance run, and departure ?

Anſw. Diſtance run, 98 leagues 5 tenths, departure leagues 376 tenths.

Queſt. 3. A Ship ſails SSW half W from 2d. 30m. ſouth latitude until the departure be 59 Leagues : I demand her diſtance run, and the latitude ſhe is in ?

Anſw. Diſtance run 125 leagues, latitude 8d. 01m. ſouth.

Queſt. 4. If a Ship ſaileth 360min. ſouth weſtward, from 21d, 59m. ſouth latitude, until (by obſervation) ſhe be in 24d. 49m. ſouth latitude : what is her courſe and departure.

Anſw. Courſe is SW by W. ½ W. and departure from the meridian is 318 minutes.

Queſt. 5. Suppoſe a Ship ſaileth 354 min. north eaſtward ; from 2d. 9m. ſouth latitude, until her departure be 150 min What is her courſe, and latitude ſhe is in ?

Anſw.

Answ. Course is NNE. $\frac{1}{4}$ east nearest, and latitude the ship is in, is 3d. 8m. north.

Quest. 6. Sailing between the north and the west, from a port in 1d. 59m. south latitude, and then arriving at another port in 3d. 08m. north latitude, which is 209 min. to the westward of the first port: I demand the course, and distance from the first port to the second?

Answ. Course is NW by N. and distance of the ports 371m. or leagues $123\frac{2}{3}$.

So much for the first part of Plain-Sailing, Traverse is next in order.

Sect. IV. *Plain-Sailing, the second part; shewing how to resolve a traverse or bring several courses into one.*

HAving learned those necessary Problems concerning a single course, the next in order is a Compound Course, commonly called a Traverse; in order to the right understanding thereof, observe the following definitions.

1. A Traverse, is when a ship (meeting with a contrary wind) saileth on several courses in 24 hours.

2. To resolve a Traverse, is to reduce or bring several courses into one; the courses are known by the compass, and the distance by the log; which in common voyages is heaved once in two hours, but to the East-Indies every hour.

3. The Log is a piece of board about seven inches long, in form like a flounder, the head off, and so fastened to a small chord (or line called the Log-Line) at one end, with so much lead at the other, that when its put into the sea, it may swim upright or endwise.

4. The Log-Line is divided into equal spaces, called Knots, by something fastened to it at every 50 feet distance for a knot. Now the Log-Line being wound on a Reel, and the Log put into the sea: If the Log-Line be veered out so fast as the ship sails, then look how many knots are veered out in half a minute's time; just so many miles or minutes doth the ship run in one hour.

5. One of these miles contain 6000 feet, and is greater then a Statute or common Mile, that being but 5000 feet; of which about $69\frac{1}{2}$ (on the meridian or any great circle) is a degree; but in the practice of Navigation, 60 miles or minutes are counted for a degree, therefore I call them minutes.

6. In the Steerage, or some other convenient place of the ship, hangeth a Table called the Log-Board, divided into 5 columns; wherein are written the Hours of the Day, Courses steered,

ſteered, Knots, &c. veered out; and laſtly the Winds; as in the table following.

The Form of the Log-Board.				
Hours of the Day.	Courſe or points.	Knots.	Fathoms of 5 Feet.	W inds
H.	C	K.	F.	W.
2	SW by S.	7	5	WNW.
4		7	5	W by N.
6	S.	8		WSW.
8		8	5	
10	NW by N½W	4	8	W by S.
12		5	4	
2		5	6	
4	SW.	7		WNW.
6		8		
8	SE.	4	4	SW by S.
10	SW.	4	5	SSE.
12	ESE.	5	3	S.

Note, The column for courſes is made ſometimes juſt before the columns for the winds, and then the three narrow columns ſtand together.

7. The day begins and ends at noon; that is, from noon to noon is the length of the day.

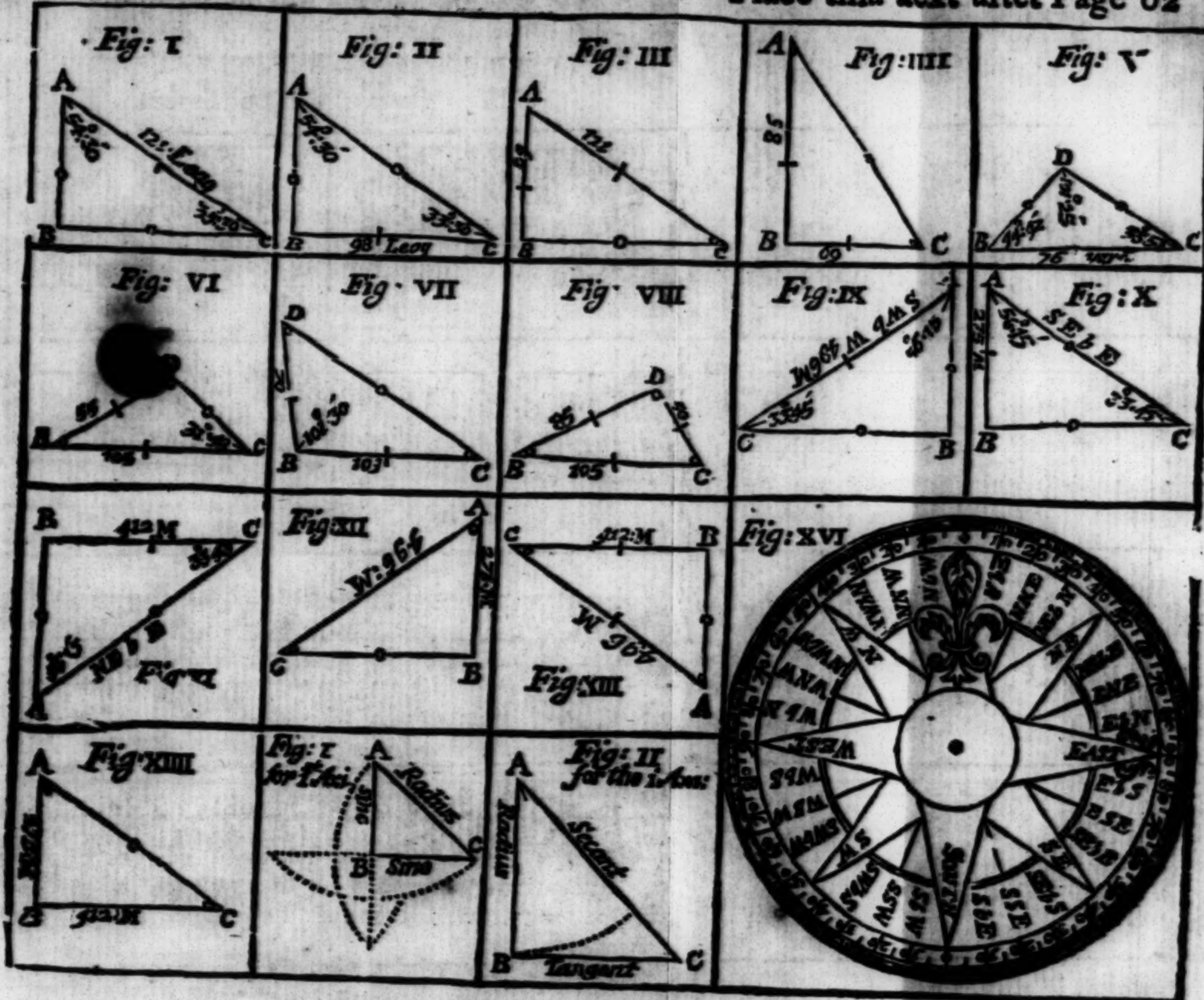
8. Every day at noon the Log-Board ought to be copied into a Log-book, ruled like the Log-Board: then muſt be caſt up how much the ſhip hath ſailed on each courſe.

9. If the ſhip ſails by a wind, its uſual to allow one point for leeward-way; ſo that when the ſhip is cloſe haled, and doth lie 5½ points from the wind, yet, her courſe corrected is 6½ points from the wind.

10. The ſeveral courſes (being corrected) and diſtances, are to be brought into one courſe and diſtance; which is called reſolving a Traverſe, and to lay it down by ſcale and compaſſes, take the four following rules, which give the points that are be-

tween

Plate 2. Place thia aext aftet Page 62



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1. S from

Number.
1
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4
5
6

tween each course, called the angle between both courses.

Rule 1. Two meridians and two parallels; the lesser course subtracted from the greater, gives the angle between both courses.

Rule 2. Two meridians and one parallel; add both courses together.

Rule 3. One meridian and two parellels; subtract the sum of both courses from 16 points.

Rule 4. One meridian, and one parallel; add 8 points, the lesser course, and the complement of the greater together; the sum is the said angle.

Note, 1. North and south are called meridians, and east and west are called parallels.

2. By the complement of the greater course, understand how much it wants of 8 points.

3. To know the meridians, and parallels, the first and second courses are compared together, and the second and third, and the third and fourth, &c.

Example. A Ship being bound to a certain Port, meeting with contrary Winds, sails first SE by S. 67 Minutes; then SE by E 53; then WSW. 45; then NE by N. 74; then West 57; and then S by E. 83 minutes: I demand the difference of Latitude, departure from the Meridian, and direct course, and distance from the first place departed? Plate 2. Fig. 15.

1. Set down the several courses and distances, with the points from the meridian, &c. as in the following table,

Number.	Courses.	Dist. in Min.	Points from the Meridian	Points for laying down.	Diff. Latitude in Minutes. North	Diff. Latitude in Minutes. South	Departure in Minutes. East	Departure in Minutes. West
1	SE by S.	67	3	3		55. 7	37. 2	
2	SE by E.	53	5	14		49. 4	44. 1	
3	WSW.	45	6	5		17. 2		41. 6
4	NE by N.	74	3	3	61. 5		41. 1	
5	West.	57	8	5				57. 0
6	S by E.	83	1	7		81. 4	10. 2	
Sumed up					61. 5	183. 7	138. 7	98. 6
Subtract						61. 5	98. 6	
Difference of Latitude						122. 2	40. 1	depart.

2. In

2. In the fifth column put the points for laying down; which are found by the four rules foregoing: for the first course always is the same with the points from the meridian; for the second course its 14 points, found by comparing the first and second courses together, in which are one meridian and one parallel; and by the 4th rule it makes 14 points for laying down: again, comparing the second and third courses it's one meridian and two parallels, which by the third Rule makes 5 points for laying down: again, the third and fourth course compared, its one meridian and two parallels; which, by the first Rule makes 3 points for laying down; and so for the rest as in the foregoing table.

3. By these points for laying down, its easy to delineate the traverse; as you see in Plate 2. Fig. 15. which is thus,

First, Draw the meridian AB, and on A draw an arch, with the chord of 60 degrees, on which arch lay three points; by it draw SE by S. line, laying thereon (from A) 67 minutes, the distance run SE by S.

Secondly, With a Chord of 60 Degrees, and one foot at the end of the SE by S. line, draw an arch, on which lay 14 points: that is, take 7 Rombs from the Scale of Rombs, and lay it twice on the said arch; by it and the end of the SE by S. line, draw a SE by E. line, making it 53 minutes long, so the second course is finished.

Thirdly, At the end of the SE by E. line, in like manner with the chord of 60 degrees, draw an arch, and thereon lay 5 points, by which and the end of the SE by E. line draw the WSW. 45 minutes long.

Fourthly, After the same manner draw the NE by N. line 74 minutes long: then the west line 57 minutes long. And then the S by E line 83 minutes long, ending in C, the place where the ship now is.

Lastly, Draw a line from C to A (the place the ship departed from) and from C let fall the perpendicular BC; then is AC the ships distance from the place of departing, AB her difference of latitude, and BC her departure from her first meridian, each being measured on the same Scale the other lines were taken from, will shew how much they are severally, and the angle BAC measured on the Scale of Chords or Rombs, shews her course.

4. Then by Problem 1. Section 4. of this Chap. find the difference of latitude and departure from the meridian; for those courses and distances severally; that is, by the first Case of plain Sailing, having the course and distance run given; to find the difference of latitude, and the departure from the meridian;

meridian; and that for each given course; which place in their proper columns, thus: if the course be north easterly, put the difference of latitude, in the north column under (North:) and the departure in the east column under (East): if the course be south easterly, then put the difference of latitude in the south column, and the departure in the east column; if south westerly, then in the south and west columns; and if north westerly, then in the north and west columns.

As for example. The first course in the foregoing traverse is SE by S that is, south easterly; the difference of latitude minutes 55. 7, place in the south column; and the departure minutes 37. 2, put in the east column; as in the table foregoing. The like observe for all the rest.

Note, When the course is E, W, N, or S. the distance sail'd, then place in the east, west, north, or south columns, as here the fifth course is west the distance 57 minutes is placed in the west column; as you see above in the Table.

5. Having found the difference of latitude and departure from the meridian for each Course, and placed them in their proper columns; add up the North, South, East, and West columns, and subtract the North and South columns, the one from the other, that is, the least from the greatest, for the difference of latitude; in like manner, the East and West columns for the departure: as in the foregoing table, the sum of the North Column 61. 5 subtract from the sum of the South Column 183. 7 the remainder 122. 2 is the difference of latitude Southerly: and the sum of the West Column 98. 6, subtracted from the sum of the East Column 138. 7, the remainder 40. 1, is the departure from the meridian easterly.

6. Then having found the difference of latitude, and departure from the meridian, the course and distance may be found by Problem 6. Section 3. of this Chap. And in this example the difference of latitude being minutes 122. 2 Southerly, and the departure minutes 40 1 Easterly, the course will be south 18d. 10m. easterly; that is, S by E $\frac{1}{3}$ E almost, and the distance minutes 128. 7 which was required.

After this manner you may work any Traverse; and for the learner's practice, I subjoin the following examples.

Example. 2. Suppose in 24 Hours a ship saileth as followeth, SW by S. 30 minutes, S 33, NNW. $\frac{1}{2}$ W. 32, SW, 39, SE, 9, and ESE. 11 Minutes: What is her difference of latitude, departure from the Meridian, direct course and distance.

Ans. Difference of Latitude Minutes 67.9 southerly departure minutes 42.8 westerly, course is south 32d. 15m. westerly, or SW by S. nearest, distance minutes 80.3 tenths.

Example, 3. If a Ship saileth by the Log-Board in 24 Hours as follows, NNE. 83 Min. SW. 74. E by S. 92. NNW. 126

S by W. 47, and NE by N. 78 minutes: what is her difference of latitude, departure, direct course, and distance run?

Answ. Difference of latitude minutes 141. 6 northerly departure 55.6 easterly, course is north 22d. 25m. easterly, or NNE. nearest, distance minutes 152.5.

Example 4. If a ship saileth W by S. 87 min. N 46, SSE. 75, E 83, NW by W 79, NE by E 57, and NW by N 64 min. I demand her difference of latitude, departure, direct course, and distance run?

Answ. The difference of latitude minutes 88.6 northerly, departure minutes 27.5 westerly, course is north 17d. 15m. westerly, or N by W. ½ W. nearest, distance 93 minutes.

Example 5. A ship saileth as followeth, NNE. 55 min. NW ¾ W 96, S by E. ¼ E. 57, WSW. ½ W. 89, NE by N ¾ E. 100. SW by W. ½ W. 54. and N by E. 50m. what is her difference of latitude, departure, direct course, and distance run?

Answ. Difference of latitude min. 131. 8 northerly, departure minutes 92. 1 westerly, course 34d. 56m. north westerly, or NW by N. nearest, and distance 161 minutes.

Example 6. A ship in 46d. 24m. south latitude saileth by the log-board in 24 hours SE. 8 min. SW by W. ½ W. 6 NE by E. 5. WNW. ½ W. 9, NW. 4, ESE. ¼ E. 3, S by E. 7. NNE. ½ E 4, and E 7 min. what is her difference of latitude, departure, direct course, distance run, and latitude she is in?

Answ. Difference of latitude min. 4. 62 southerly departure min. 6. 17 easterly, course is south 53d. 10m. easterly or SE ¾ E distance run min. 7. 71, and latitude 46d. 29m. south.

Example 7. Admit a ship in 1d. 30m. north latitude, sails NNE. 6 min. SE by S. ½ E. 5, NE by E. ½ E. 4 WNW ¾ W. 8. SW by S. ½ W. 7. NW by N. 4. ENE. 5. SW. 7. and SE by E. 5 min. I demand her difference of latitude, departure, direct course, distance run, and what latitude she is in?

Answ. Difference of latitude minutes 2.40 southerly departure min. 1. 59 westerly, course is south 33d. 31m. westerly, or SW by S. distance minutes 2. 88 and latitude she is in 1d. 28m. north.

Thus much for the second Part of Plain-sailing, called a Traverse, we go on to the use of an oblique Triangle in Plain-sailing.

Sect. V. Plain-sailing, the third part; or the doctrine of oblique angles applied in problems of sailing by the Plain Chart.

ALtho' this part of plain-sailing is the least useful, and most difficult, yet for the learner's diversion I add some problems.

Problem 1. *Suppose two ports lie north and south, and a ship sails from the northermost* SE 68 *minutes; another from the southermost*

southermost sails NE *by* N. *till she meet the first ship: I demand the distance of the port, and the second ship's distance run?*

In the oblique triangle ADE, Plate 3. Fig. 1.

Let A represent the northermost } Port
D the southermost }

Side { AE the first——— } ship's course and distance.
{ DE the second——— }

E the place where the ships meet.

Here are two angles and one side given, and therefore by Chap. 2. Sect. 3. Prob. 5. Case 1. of Oblique Angles.

1. For the side AD the distance of the two ports, the proportion is,

S. ADE · side AE :: S. AED .. side AD.

S. 3 Points.. 68 min. :: S. 9 points .. min. 120. 5 tenths.

Note, When an angle exceeds 8 points, subtract it from 16; as here, 9 points being subtracted from 16, the remainder 7 points, is to be used instead of it.

2. For the side DE the second ship's distance, the proportion is;

S. ADE .. side AE :: S. DAE .. side DE.

S. 3 points .. 68 min. :: S. 4 points .. min. 86. 2 tenths.

Problem 2. Suppose two ports lie NE. and SW. and a ship sails from the southermost ESE. 45 minutes, another from the northermost runs 72 minutes, and then meets the first ship; I demand the course steered by the last, and the distance of the port?

In the oblique triangle ADE, Plate 3. Fig. 2.

Let A represent the southermost } port.
D the northermost——————— }

Side { AE the first——— } ship's course and distance.
{ DE the second—— }

E the place where the ships meet.

Here are two sides and one angle opposite given, and by Chap. 2. Sect. 3. Prob. 6. Case 2 and 3. of Oblique-angles.

1. For the angle ADE the second ship's course, the proportion is,

Side DE .. S. DAE :: side AE .. S. ADE.

72 min. .. S. 67d. 30m. :: 45 min .. S. 35d. 15m. which subtract from SW. 45d. makes the course 9d. 45m. south westerly, or S. $\frac{3}{4}$ W.

2. For the side AD the distance of the two ports, the proportion is,

S. DAE ·· side DE :: S. AED ·· side AD.

S. 67d. 30m. ·· 72 min. :: S. 77d. 15m. ·· 76 min. in dist.

Problem 3. Two ships sail from a certain road, one sails SSE. 50 minutes, the other SSW. 35 minutes. I demand their bearing and distance?

In the oblique triangle ADE. Plate 3. Fig 3.
Let A represent the road.

Side { AD the first—— } ship's course and distance.
{ AE the second— }
{ DE the bearing and distance of the two ships.

Here are two sides and one angle between them given; and by Chap. 2. Sect. 3. Prob. 7. Case 4 and 5 of Oblique-angles.

1. For the angles ADE and AED; their bearing.

Side { AD 50 min.	From the three angles— —180d. 00m.
{ AE 35 min.	Subtract the angle DAE — 45d. 00m.
Sum sides 85 min.	Sum of ADE and AED — 135d. 00m.
Diff. sides 15 min.	The half sum ADE and AED - 67d. 30m.

Sum sides ·· diff. sides :: T ½ sum angles ·· T ½ diff. angles. 85 minutes ·· 15 min. :: T. 67d. 30m. ·· T. 23d. 05m.

The half diff. of the angles 23d. 05m.

Added, is the greater angle 90d. 35m. AED.

Subtracted, is the lesser angle 44d. 35m. ADE.

which added to SSE. 22d. 30m. is south easterly 66d. 55m. and north westerly 66d. 55m. that is ESE. and WNW. nearest, is the bearing of the two ships.

2. For the side DE their distance, the proportion is,

S. ADE ·· side AE :: S. DAE ·· side DE required.

S. 44d. 25m. ·· 35 min. :: S. 45d. 00m. ·· min. 35. 4 tenths.

Problem 4. Suppose a ship sails NE. 50 leagues, then south easterly 85 leagues; and then forced back by foul weather 105 leagues to the place from whence she first sailed: I demand her second course, and her last course back?

In the oblique triangle ADE, Plate 3. Fig. 4.
Let A represent the place sailed from at first.

D { the } second place, and DE second course and dist.
E { } the third place, and DA third course and dist.

Here are three sides given; and by Chap. 2. Sect. 3. Prob. 8. Case 6. of Oblique-angles, the proportions are;

1. For FE the difference of the Segments AB and BE; the operation is,

Leagues	
Side { DE 85	Side AE.. sum DE & DA :: diff DE & DA.. FE diff deg.
{ DA 50	105 leag. ·· 135 leagues :: 35 leagues ·· 45 leag.
Sum —135	45 FE difference of the segments AB, and BE.
Diff. — 35	105 } the half is { 75 BE the greater segment.
	60 } { 30 AB the lesser segment.

2. For

2. For the angles DAE and AED, the proportions are; Hypotenuse AD ·· radius :: leg AB ·· sc. DAB or DAE.

50 leagues ·· S. 90. :: 30 leag. ·· S. 36d. 53m.
Subtract from — — 90. 00m.
Resteth angle DAE — 53d. 07m. which being added to NE makes N easterly 98d. 07m. or south easterly 81d. 53m. so that the course from E to A, is W by N. $\frac{3}{4}$ W. back to the place first sailed from. And again; hypotenuse DE ·· radius :: leg BE ·· sc. BED or AED.

85 leagues ·· S. 90d. :: 75 leag. ·· S. 61d. 55m.
Subtract from — — 90d. 00m.
Resteth angle AED — — 28d. 05m.

Which subtract from the south easterly 81d. 53m. leaveth 53d. 45m. or SE $\frac{3}{4}$ E nearest for the second ship's course from D to E.

These are the kinds of Oblique Questions, though multitudes may be proposed, of which here followeth a Taste, to exercise the young learner; of all them to be resolved by the foregoing.

Problem 5. Suppose a merchant-ship in 45d. 30m. North Latitude, falls into the hands of pyrates, who take away his sea-compass; after which he saileth as directly as he can 67 leagues between the south and west, and at the end of two days meets a ship of war who also had been the day before in 45d. 30m. North Latitude, and had sailed thence SE by S 39 leagues; now the merchant-ship left those pyrates lying to and fro where they robbed him, and the man of war being desirous to find them; I demand what course he must shape to speak to them?

Answ. North 61d. easterly, or NE by E half E.

For this Problem in an Oblique Triangle, two Sides and one angle opposite given; to find the angle opposite to the other Side; which triangle is thus made.

1. Describe a circle with the chord of 60 deg. and quarter it, on whose diameter set N.E.S.W. and A at the center; but (always) N at the upper part, and at the E the right hand of the circle.

2. Then lay 3 points from S. to E. on the circle, and draw the SE by S line, AD 39 leagues long.

3. With 67 leagues, and one foot on D, with the other cross the line WAE (produced to the eastward) in C, the place where the ship fell in with those pyrates.

4. Then a line being drawn from C to D it's done: for A and C are both in the latitude of 45d. 30m. and AD represents the man of war's course and distance, and CD the merchant-man's after he lost his compass; so that the angle ACD being measured on the Scale of Chords, will shew her course from the

the weſt towards the ſouth, the oppoſite point is the man of war's courſe north eaſterly, to find thoſe pyrates.

Problem 6. Coaſting along ſhore, I ſee two capes of land: the firſt did (by the compaſs) bear N. the ſecond WNW. then I ſtood away NW by N 9 minutes, until the firſt beared from me E. by S. and the ſecond S. by E. the bearing and diſtance of them is required.

Anſw. South 38d. 05m. weſterly or S. W. by S. half W. and NE. by N. half E. neareſt, diſtance is minutes 6.22 parts of a hundred.

Note, In all queſtions of this nature, you muſt, as a preparative work, find the diſtance of each cape from the ſhip at firſt ſeeing them, or at laſt ſetting them; which is evident by the projection, thus,

1. Having drawn a circle, quartered it, and placed the letters N, S, E, W, and A: as directed in the laſt Prob. produce AN up higher, becauſe the firſt bearing is north.

2. Lay 6 points from N. towards W, and draw the WNW. line from the ſecond cape's bearing.

3. Lay 3 points from N towards W, and draw the NW by N. line 9 minutes long, from A to D, the ſhip's courſe, and diſtance.

4. Then lay 7 points from S. towards E, and laying a ſcale on it and A. draw an E. by S. line from D. parallel, to the edge of the ſcale, to cut the north line in B. the firſt cape.

5. In like manner, lay 1 point from S. towards E, and lay a ſcale on it and A, draw a S. by E. line from D. parallel to the edge of the ſcale, to cut the WNW. line in C. the ſecond cape.

6. Draw a line from B to C. and it's done: for the line B. C. repreſents the bearing and diſtance of the two capes from each other, which being meaſured on the ſame ſcale A.D. was taken from, will ſhew their diſtance aſunder. And the angle ABC meaſured on any Scale of Chords, will ſhew their bearing to the ſouth weſterly, or north eaſterly.

But to find theſe things by Trigonometry it's neceſſary to find the ſides AB and AC; or elſe the ſides DB and DC; which is done in two oblique triangles ABD, and ACD, in each all the angles and one ſide is given, to find a ſide.

And Note, A repreſents the place of the ſhip at firſt ſeeing the capes, and D the place at laſt ſetting them.

So that, when the ſides AB and AC, or DB and DC are found; then is there either the oblique triangle ABC or BDC to work in; then BC (the ſide common to both triangles) with its agreeing angles may be found, by which their bearing and diſtance from each other is diſcovered; and in each

triangle

triangle there is two ſides and one angle between them given; to find the other angles and third ſide; which is to be wrought as the third Problem of this Section.

Problem 7. Suppoſe a ſhip ſailing NW. two iſlands appear in ſight, one bears WNW. the other N. from the ſhip, and when the ſhip hath ſailed 6 minutes further, the firſt bears W by S. and the other NE. Their bearing and diſtance is required.

Anſw. South 58d. 46m. weſterly, or SW by W. ¼ W. and NE. by E. ¼ E. diſtance is minutes 9. 7 tenths. found out as before in the laſt problem.

Problem 8. Three ſhips ſail from one port, the firſt ſails SW by W. the ſecond W. by S. ½ W. and the third NW. by W. 8 minutes; then the firſt bears from the third S. by W. the ſecond bears from the third SSE. The firſt and ſecond ſhip's diſtance ſailed, and their bearing and diſtance from each other is required.

Anſw. Firſt ſhip's diſtance minutes 10.45. ſecond's diſtance minutes 4.65. their bearing north 37d. 14m. eaſterly, or NE. by N ¾ E. and SW by S ¾ W diſtance minutes 6.75. This alſo is wrought by the direction of the 6th problem.

Problem 9. Admit ſailing along ſhore I ſee two head-lands, the eaſtermoſt bears NNE. and the weſtermoſt NW. off me, at the ſame time an iſland bears S. then after I ſailed W 8 minutes the firſt did bear NE. by E ½ E. the ſecond NNE. and the iſland ESE. from me: the bearing and diſtance of theſe places from each other are required?

Anſw. The head-lands bear north 88d. 53m. weſterly or eaſt and weſt neareſt, diſtance minutes 7.95. The eaſtermoſt headland bears from the iſland north 14d. 30m. E. or N. by E. ¼ E. and S. by W. ¼ W. diſtance minutes 9.15. and the weſtermoſt head-land bears from the iſland north 32d. 15m. weſt, or NW. by N. and SE. by S. diſtance, minutes 10.6 tenths.

This is of the ſame nature with the ſixth Problem, only there are three things to be found as preparative, *viz.* the diſtance of each head-land and the iſland from the ſhip, and conſequently in three triangles both in the preparative, and ſubſequent work, proportions are made, which makes up nine ſeveral ſtatings to reſolve this Problem.

The next 4 Problems are uſed in turning to windward.

Problem 10. Suppoſe the wind ſouth, and a ſhip is bound to a port 400 leagues directly to windward, and makes her way good within 6¾ of the wind: I demand her diſtance ſailed upon each tack, to gain the ſaid port?

 Anſw.

Answ. 823 leagues is the ship's distance sailed on each tack. For its thus projected by the Plain Scale.

1. Describe a circle with the chord of 60 degrees, quarter it and place N. S. E. W. and A, as directed in Prob. 5.

2. Lay 400 leagues on the meridian, from A, (southerly) to B. the place the ship is bound unto.

3. From S lay $6\frac{3}{4}$ points towards E, and by it from A, draw the ESE$\frac{3}{4}$E line AC.

4. Also lay $6\frac{3}{4}$ points from S towards W, and laying a Scale on it and A, draw a WSW$\frac{3}{4}$W. line from B, parallel to the edge of the Scale, to cut the ESE.$\frac{3}{4}$E. line in C, the place where the ship tackt, and it's done:

For A represents the place the ship sails from, B the port 400 leagues directly to windward, AC equal to CB, the ship's distance sailed on each tack; which being measured on the same Scale AB was taken from, will shew how much it is.

But to work it by Trigonometry, in the oblique triangle ABC, all the angles and one side AB being given, the other sides AC and CB are found as in the First problem of this Section: and because two angles are equal, the sides opposite to them are also equal; therefore one proportion finds AC and CB.

Problem 11. The wind SW. and a ship plying to windward, (making one or many boards) having run 900 leagues; that is, 450 with the larboard-tack aboard, and 450 with her starboard-tack aboard, it got 300 leagues directly to wind-ward: I demand how near the wind she makes her way?

Answ. 70d. 32m. or 6 $\frac{1}{4}$. points from the wind. Which is thus delineated by the Plain Scale.

1. A circle being described, quartered, and lettered, as hath been directed in the former Problems: then lay 4 points from S towards W. and by it and A, draw a (S.W.) line 300 leagues long from A to B.

2. With 450 leagues (taken from the same Scale AB was taken from) and one foot on A, make an arch; also with the same, and one foot on B. cross the former arch in C.

3. From C draw lines to A and B, and it's done: for the angle BAC equal to the angle ABC measured on any Scale of Chords, sheweth how near the wind the ship makes her way.

But by Trigonometry, thus; in the triangle ABC all three sides are given, to find the angles, which may be done by the fourth Prob. of this Sect. Otherwise thus; because A C and BC are equal; wherefore let fall a perpendicular from C to the S.W. line AB, as AD; which cuts AB in the middle, making AD 150 leagues equal to BD, and so reduce the oblique triangle ABC into two equal right-angled triangles, AD and BDC: whose

whose sides and angles in each triangle are equal to one another; so that one proportion serveth to answer the question.

For in the right-angled triangle ACD: there is given the hypotenuse AC 450 leagues, and leg AD 150 leagues; to find the angle CAD which is equal to the angle CBD (the ship's course from the wind) which is done by Axiom 1. of Plain Trigonometry, thus,

Hypot. AC ·· Radius :: leg AD ·· S. ACD = BCD
450 Leag. ·· S. 90d. :: 150 Leag. ·· S. 19d. 28m.
Which subtract from — — 90d. 00m.

Remainder is the angle CAB = ABC 70d. 32m. or $6\frac{1}{4}$ pts. the ship's course from the wind SW.

Problem 12. Admit a ship bound to a port that lieth SW by S. 484 leagues distance, the wind S by E. and makes her way good within $6\frac{1}{4}$ points, of the wind. I demand how far she must sail upon each tack, to gain the port?

Answ. 690 leagues on her larboard tack, and 328 leag. on her starboard tack. Thus demonstrated by the Plain Scale

1. The circle described, quartered, &c. as formerly, lay 1 point from S towards E, and by it and A, draw a S by E, line AB representing the wind.

2. From S towards W. lay 3 points, and by it and A draw a SW by S line 484 leagues long from A to C.

3. From the wind (S by E) lay $6\frac{1}{4}$ points towards W, and by it and A draw a (SW by W. $\frac{1}{4}$ W) line AD.

4. Likewise lay $6\frac{1}{4}$ points from the wind (S by E.) towards E, on it and A, lay a Scale; then from C draw a (E by S $\frac{1}{4}$ E) line to cut the wind, (S by E,) line in B, and the SW. by W $\frac{1}{4}$ W line in D. and it's done. For AD, and DC represent the ship's distance sailed on each tack, which being measured on the same Scale AC was taken from, will shew how much the distance sailed on each tack is.

By Trigonometry its thus: in the oblique triangle ACD, all the angles and one side is given; to find the other two sides which is done by the first Problem of this Section, in Page 67.

As S. ADC ·· side AC :: S. ACD ·· side AD.

As $3\frac{1}{2}$ points ·· 484 leag. :: S. $10\frac{1}{4}$ points ·· 690 leagues is the distance sailed on her larboard tack.

As S. ADC ·· side AC :: sine CAD ·· side CD.

S. $3\frac{1}{2}$ points ·· 484 leag. :: S. $\frac{1}{4}$ points ·· 328 leagues is the distance sailed on the starboard tack.

Problem 13. If two ports lie SW by S. and NE by N. distance 484 minutes, the wind S by E. and a ship sails from the northermost port close upon a wind 695 minutes, with her larboard-tack aboard,

aboard, and 332 with her ſtarboard-tack aboard, and then arrives at the ſouthermoſt port. I demand how near the wind ſhe makes her way good upon each tack.

Anſw. 70d. 30m. on one tack, and 70d. 40m. on t'other; which is 6¼ points from the wind? that is SW by W. ¼ W. with her larboard-tack, and E by S. ¼ E, with her ſtarboard-tack.

This done by the Plain-Scale.

1. Deſcribe a circle with a chord of 60 degrees, quarter it, &c. as formerly, then lay 3 points from S towards W, and by it and A draw a SW by S line 484 minutes long, from A to B.

2. Lay 1 point from S towards E, and by it and A draw the S by E line AC.

3. With 695 minutes (taken from the ſame Scale AB was taken from) and one foot on A make an arch: alſo with 332 minutes, and one foot on B. croſs the former arch in D.

4. From D draw lines to A and B, and continue the line BD, till it cuts the S by E line AC in C, and it's done: for the angles DAC, and ACD meaſured on the Scale of Chords or Rumbs, will ſhew how near the wind the ſhip makes her way good on each tack.

By Trigonometry, its thus: In the oblique triangle ABD, all the ſides are given, to find the angles that is, AD 695 minutes, AB 484, and BD 332; to find the angles BAD, and BDA; which is done by the fourth Problem of this Sect. in Pages 68 and 69.

The next Problems are concerning Currents.

Problem 14. Suppoſe a current ſets NNE. 7 minutes in a certain time, and a ſhip ſails SSW, (by the log.) 9 minutes in the ſame time: what is her true courſe and diſtance?

Anſw. SSW. is the ſhip's true courſe, and diſtance 2 minutes: which is evident by the Plain Scale, thus;

1. Having done as formerly as directed, in making a circle &c. Lay 2 points from S towards W, and by it and A draw a SSW. line 9 minutes long from A to B.

2. With 7 minutes (taken from the ſame Scale AB was taken from) and one foot on B, croſs the line AB in C, ſo that BC may be NNE. and it's done: for AC meaſured on the ſame Scale ſheweth the ſhip's true diſtance, or thus,

From the ſhip's ſuppoſed diſtance	SSW. 9 min.	AB.
Subtract the current's motion	NNE. 7 min.	BC.
Remains the ſhip's true diſtance	SSW. 2 min.	AC.

The like is done for the two next following problems.

Problem

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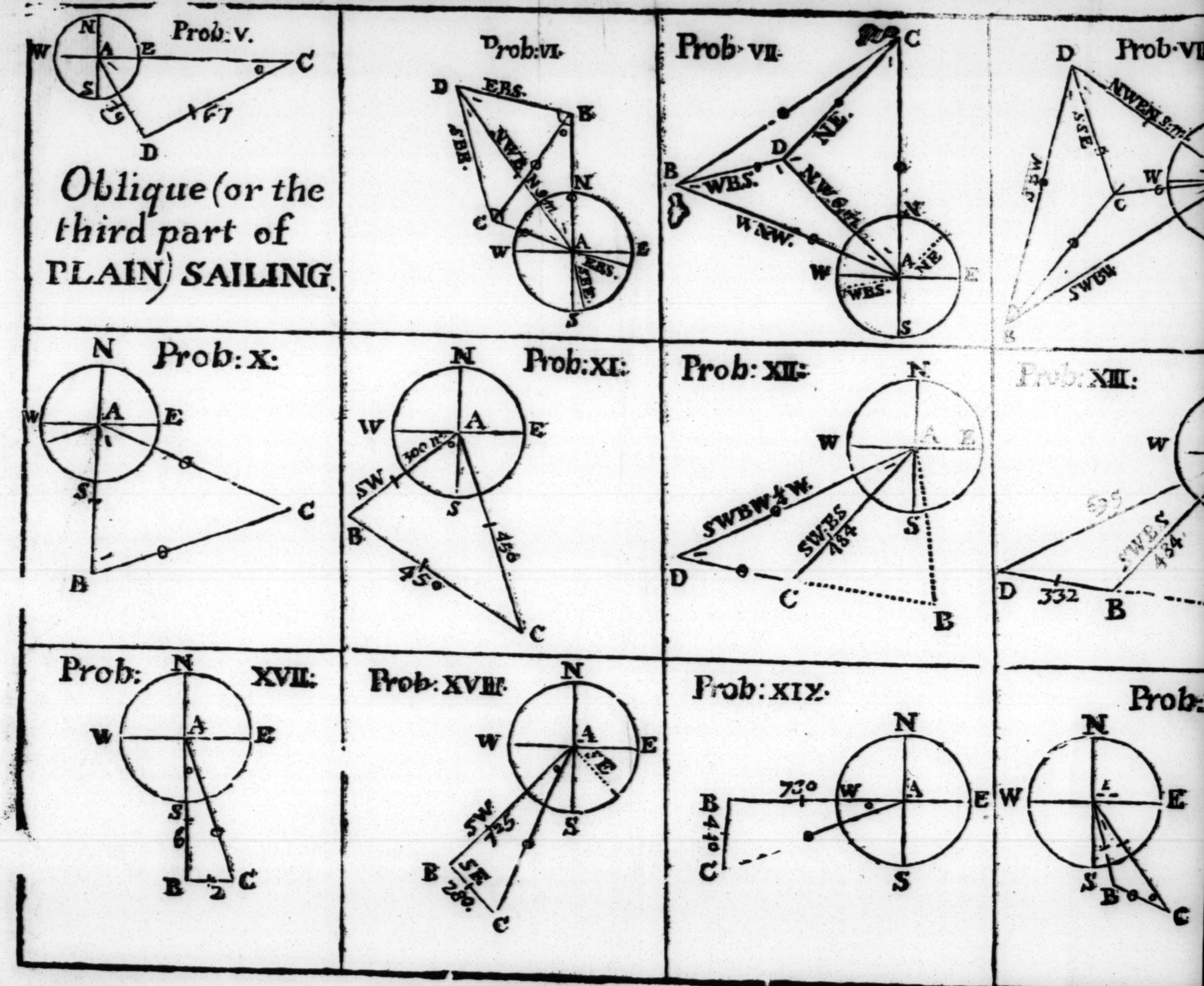
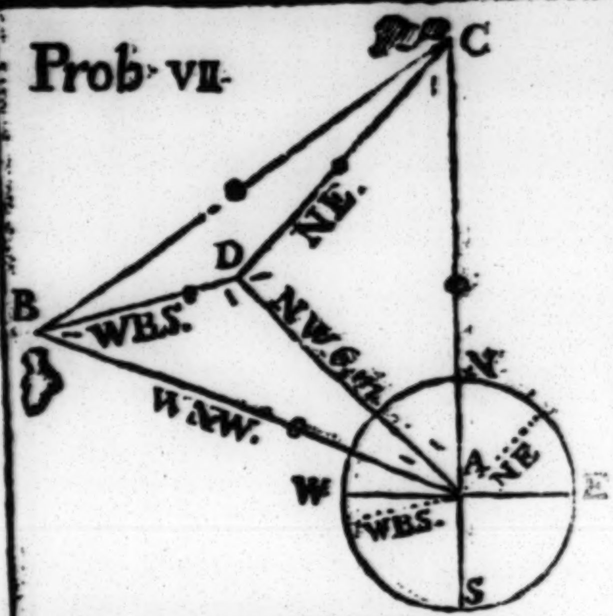
Plate 7.

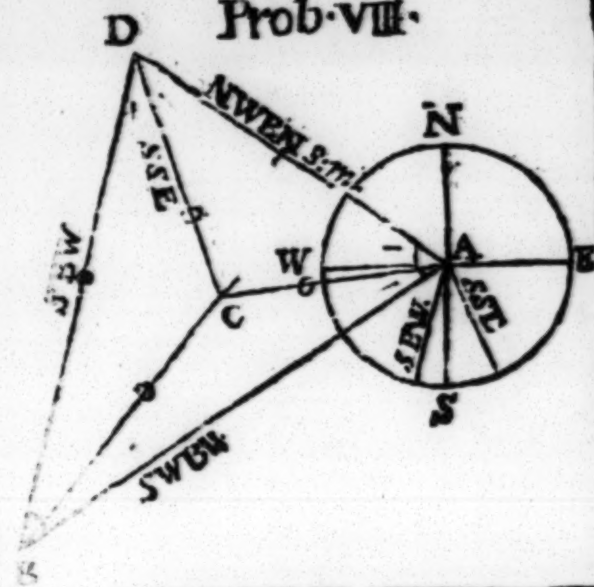

Prob: V.
Oblique (or the third part of PLAIN) SAILING.
Prob: VI.
Prob: VII.
Prob: VIII
Prob: X:
Prob: XI:
Prob: XII:
Prob: XIII:
Prob: XVII:
Prob: XVIII.
Prob: XIX.
Prob:

Place this next after Page 79

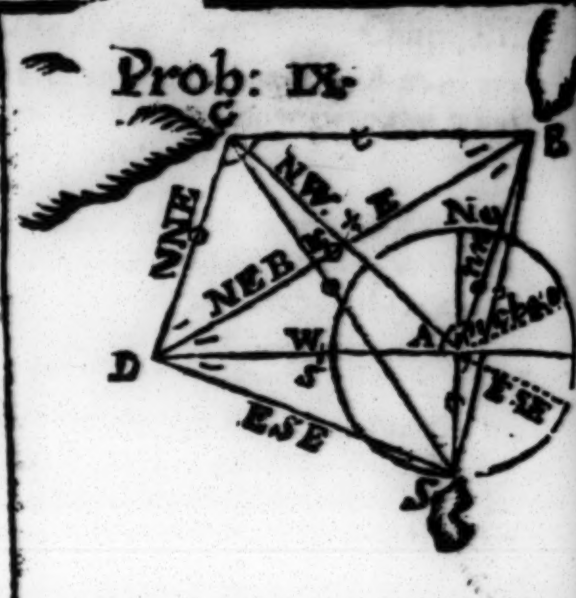
Prob: VII.



Prob: VIII.

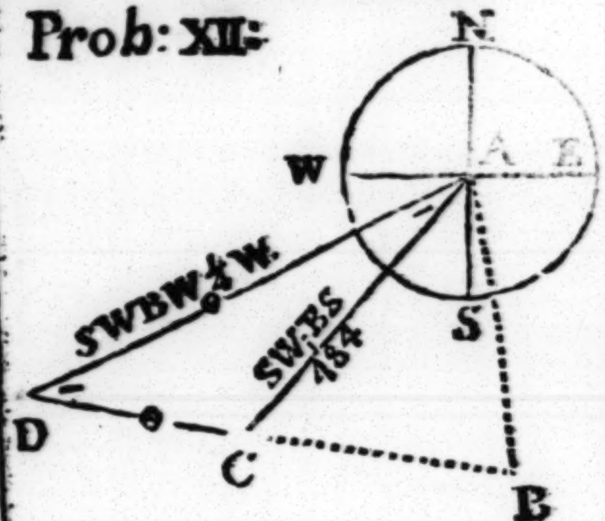


Prob: IX.

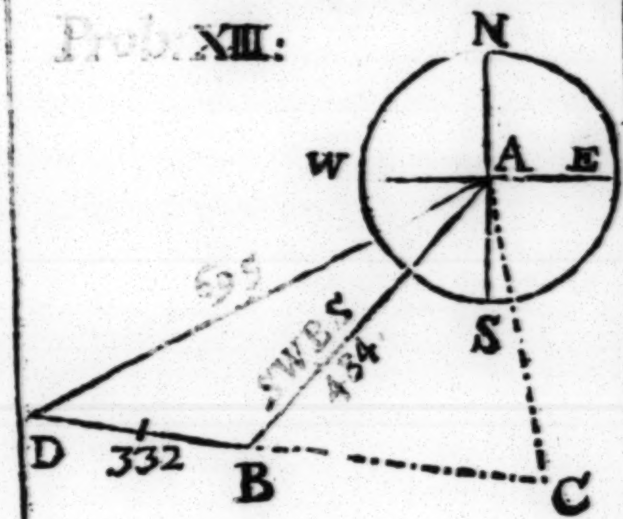


:XI:

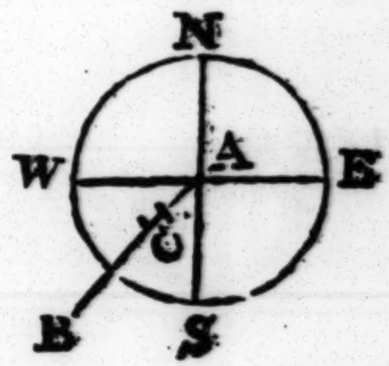
Prob: XII.

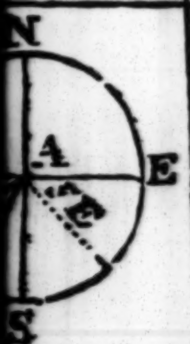


Prob: XIII.

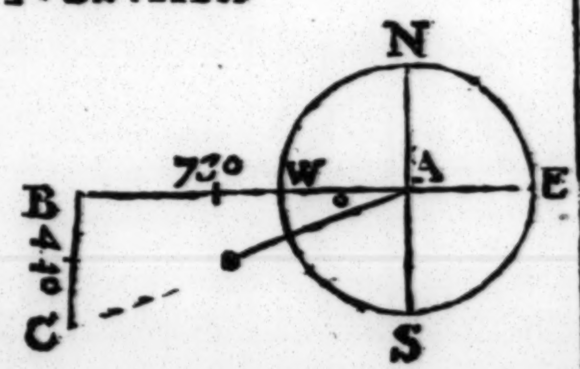


Prob: XIV.

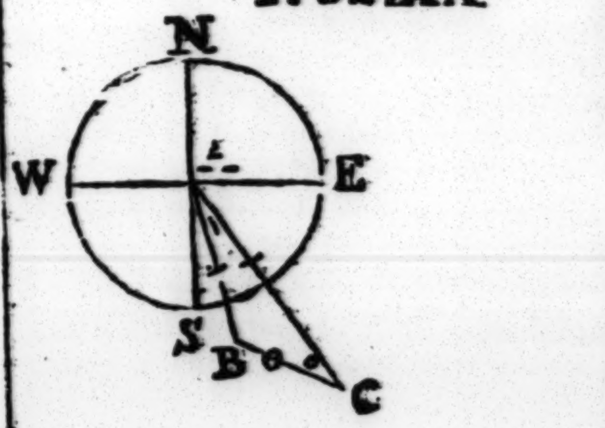




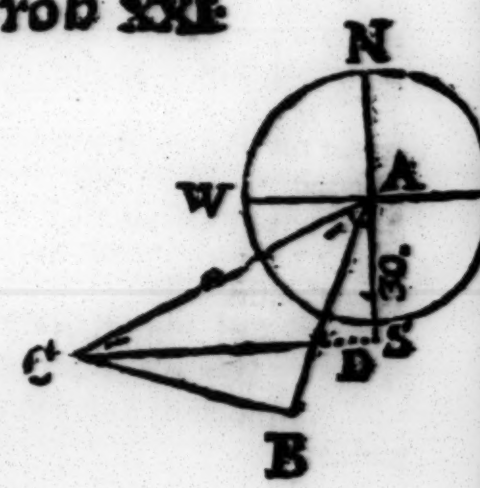
Prob: XIX.



Prob: XX.



Prob XXI.



Problem 15. If a current ſets E, 4 min. an hour, ſhip ſails E, (by the log.) 5 minutes in an hour; the ſhip's true courſe and diſtance is required.

Anſw. The ſhip's true courſe is eaſt, diſtance 9 minutes.

Problem 16. A current ſetting WSW. 90 minutes is a known time, and a ſhips ſailing ENE (by the log.) 60 minutes in the ſame time: what is her true courſe and diſtance?

Anſw. WSW. 30 minutes, ſo that ſhe is fallen a ſtern.

Problem 17. Suppoſe a current ſetteth E. 2 minutes an hour, and a ſhip ſails S. 6 minutes an hour: what's her true courſe and diſtance?

Anſw. South 18d. 26m. eaſterly, or S by E ¾ E. is the ſhip's true courſe, diſtance min. $\frac{3}{10}$

By the Plain Scale it's thus demonſtrated.

1. After a circle is deſcribed, &c. as formerly, then lay 6 minutes on the meridian from A to B.

2. Draw BC parallel to WAE, and thereon lay 2 minutes from B (towards the right-hand) to C.

3. Then draw a line from A to C, and it's done; for the angle BAC is the Ship's true Courſe, and AC her true Diſtance.

By Trigonometry its thus; the triangle ABC is a right-angled triangle, in which both legs are given, to wit, AB 6 minutes, the ſhip's ſuppoſed diſtance, and BC 2 minutes, the current's motion, to find the angle BAC her true courſe, and AC her true diſtance; which is done by Axiom the Firſt of Plain Trigonometry.

In like manner Problem 18 and 19 is performed.

Problem 18. If a ſhip ſails (five days together) by the log, SW 725 minutes: in a current that ſetteth (in the ſame time) S.E. 280 minutes: what's the true courſe and diſtance?

Anſw. South 23d. 52m. weſterly, or SSW. is the ſhip's true courſe, diſtance 775 min.

Problem 19. Admit a ſhip ſails W. 730 minutes thwart a current ſetting to the ſouthward; and then by obſervation finds the difference of latitude is 4d. or 240 minutes. I demand her true courſe and diſtance. *Anſw.*

Answ South 71d. 48m. westerly, or WSW. ½ W. is the ship's true course, distance 768 minutes.

Problem 20. If a ship sails S by E. 36 minutes in a current, and then arrived at a port, which lieth from the place she departed from SE by S. distance 54 minutes: I demand the current's motion both in quality, and quantity; that is, how it setteth, and how fast.

Answ. Current setteth south 67d. 29m. east, or ESE. is the drift of the current as to quality and minutes, 24. 9 tenths is its drift as to quantity. By the Plain Scale, thus.

1. As before, having described the circle, &c. lay 1 point from S. towards E, and by it and A draw a S by E. line 36 minutes long, from A to B.

2. Lay 3 points from S. towards E. and by it and A, draw a SE by S. line, 54 minutes long from A to C.

3. Then draw a line from B to C, and it's done: for the angle ACB measured (on the scale) sheweth the current's motion as to its quality, which way from the SE by S. and the side BC measured (on the scale) sheweth the current's motion as to its quantity, how much, or how fast.

But by Trigonometry, it's thus,

In the oblique triangle ABC, there is given, two sides and an included angle; that is, the side AB 36 minutes, the side AC 54 minutes, and the angle BAC two points or 22d. 30m. to find the angles ABC, ACB and the side BC; which is done by the third problem of this section.

Problem 21. Suppose a ship sails from a certain cape or headland and (by the Log) in 24 hours, runneth SSW. 49 minutes in a current setting between the N. and the W. and then the cape did bear ENE. and by observation the ship's difference of latitude was 30 minutes, I demand the current's motion: that is, upon what point of the compass, and how fast?

Answ. The current sets north 74d. 07m. west, or WNW ½ W. nearest, and at the rate of minutes 2.32 an hour. Thus demonstrated by the Plain Scale.

1. After the circle is described, quartered, &c. lay two points from S. towards W, and by it and A, draw a SSW. line 49 minutes long, from A to B.

2. Lay six points from S. towards W, and by it and A draw a WSW. and ENE. line AC.

3. Lay

3. Lay 30 minutes on the meridian AS from A to D, and from D draw a west line parallel to AW, to cut the WSW line in C.

4. Then draw a line from B to C, and it's done: for the angle ABC being measured on the scale, sheweth the current's motion from SSW. and the side B C being measured sheweth how fast.

By Trigonometry its thus;

1. In the right angle triangle ADC, there is given, the leg AD 30 minutes, angle DAC 6 points, and angle ACD 2 points to find the hypotenuse AC, which is done by Axiom first of Plain Trigonometry.

2. Then in the oblique triangle ABC, there is given, the side AB 49 minutes, the side AC found before, and the included angle BAC 4 points or 45d. to find the angle ABC (the current's motion from SSW.) and the side BC, its motion how fast.

Let this suffice, for (tho' many more problems might be invented in) the first Part of Navigation, commonly called Plain-sailing. Mercator's-sailing is next in order.

CHAP. IV.

The second part of Navigation, *or the doctrine of* Plain Right Angle-Triangles, *applied in problems of* Mercator's-Sailing.

I Count it necessary to describe Mercator's-chart, and shew the uses of it, before the problem of sailing by it, which by this method will the easier be understood.

Sect. I. The description and use of Mercator's-chart.

THIS Projection supposeth the earth and sea to make one round Body or Globe, in order to the right understanding of it, observe the following definitions.

1. Upon this earthly Globe is imagined two opposite points, one called the north pole, the other the south pole; as P, and I. Plate 5. Fig. 1.

2. In the middle between those two poles, or equally distant from each, is drawn a line round the globe, called the Equator, from which latitude taketh its beginning, and in which longitude is reckoned; as Æ A Q.

3. Any circle drawn through both poles, is called a meridian. as PMI. PNI, &c. answerable thereunto as any north or south line drawn in the chart.

4. Those

4. Those circles which are parallel to the equator, are called parallels of latitude; as *a l t*, *z l t*, &c. and are represented in the chart by the east and west lines.

5. Latitude of a place is the (nearest) distance of any parallel passing over it from the equator; from thence counted both ways to each pole, ending in 90 degrees the greatest latitude.

6. North latitude, is on that side the equator towards the north pole, and south latitude on the other side of the equator, towards the south pole.

7. Difference of Latitude, is the (nearest) distance between any two parallels, and sheweth how far one place is to the northward or southward of another; it never exceeds 180 degrees.

8. Longitude, is reckoned in the equator, round which (by some) its counted increasing to the eastward till it ends (where it first began) in 360 degrees the greatest longitude: others (as Mr. Wakely in his Mariner's Compass rectified) reckon it from one meridian both easterly and westerly, till both accounts meet at 180 degrees in the opposite meridian, as the aforesaid book begins longitude at the meridian of London, and from thence counting easterly, east longitude 180 degrees, and westerly, west longitude 180 degrees, at which both longitudes end.

9. Difference of longitude is that distance or portion of the equator contained between the meridians of any two places, and sheweth (in the equator) how far the meridian of one place, is to the eastward or westward of the meridian of another, and never exceeds 180 degrees.

From these definitions, or principles, there must necessarily follows these Theorems.

1. The distance of any two meridians, in any parallel of latitude, is lesser than their distance in the equator.

2. The degrees of longitude diminish towards each pole, and the nearer the pole, the lesser they are.

3. The degrees of longitude are equal in all places or parts of the globe.

4. The Plain Chart, which counteth the degrees as well of longitude, as of latitude in all places to be equal, is notoriously false.

5. Mr. Wrights Projection (commonly known by the name of Mercator's Chart) wherein though the degrees of longitude are equal, having the meridians parallel to one another; the degrees of latitude are enlarged towards each pole, in the same proportion as the degrees of longitude diminish on the globe, which will in all respects agree with the globe, and is a true way of sailing, let some say what they will to the contrary.

These

These Definitions and Theorems duly considered, there needs no more for the description of this Chart, it having only this difference from the Plain Chart, before described in Chapter 3. Section 2. in Page 51. that the equator is divided and numbered in degrees, as the graduated meridian is; and without any further description, the uses are as follow.

Problem 1. To find the latitude of any place in the Chart.

This was taught before in the use of the Plain Chart, in Page 52 and needs no further rule and example.

Problem 2. To find the longitude of any place in the Chart.

Rule 1. Take the nearest distance from the proposed place to any meridian.

2. Move the compasses (being kept at that distance) with one foot on the meridian, till both feet come to the equator, and the foot which stood on the proposed place sheweth its longitude required.

Example. I demand the longitude of the Lizard in England?

Answ. 9d. 40m. according to the old way of computing the longitude from the meridian of Pico Teneriff; but 5d. 24m. west longitude, counting east and west longitude from the meridian of London, according to the Mariner's Compass rectified.

Note, Some charts begin longitude at the Lizard, counting from thence eastward and westward.

Problem 3. To find the course or bearing of any two places in the chart.

This is done as before in the use of the Plain Chart, in Page 52, and needs no Example.

Problem 4. To find the distance of any two places in the Chart.

In this Problem are four cases; the two places may be situated under one meridian, under the equator, or in one parallel, or they may differ both in latitude and longitude.

Case 1. Two places under one meridian, (that is, they differ only in latitude) being given; to find their distance.

The Rule. Find the difference of latitude between the two given places, and it's the distance required.

How

How to find the difference of latitude between the two places, has been taught in Chap. 3. Section 3. of Plain-sailing, in Page 55.

Case 2. Two places in the equator given; to find their distance.

The Rule. Find the difference of longitude between them, and it's the distance required.

How to find the difference of longitude, will be shewed in the next section.

Case 3. Two places in one parallel (that is, they differ only in longitude) being given, to find the distance.

The Rule. 1. Take the distance between the given places by the compasses.

2. Lay that distance on the graduated meridian, so that one foot may be as many degrees above the parallel of the given places, as the other below it; there stay the compasses.

3. Count the degrees between the feet of the compasses and it's the distance required.

Example. I demand the distance from the Lizard in England, to Pengwin island on the coast of New-found-land, both being in the latitude of 50d. 00m. north or near it.

Here the distance from the Lizard to Pengwin island, applied to the meridian as directed, will reach from 36d. 30m. to 63d. 30m. the latter being as much above 50d. 00m. as the former is below it; and the degrees intercepted are 27 degrees, or 540 leag. which is the distance required. Or thus,

Take the length of a degree in the given latitude, as here from 49d. 30m. to 50d. 30m. turn that over in a strait line from the Lizard to Pengwin island, and it's 27 times; which shews the distance 27 degrees as before.

Case 4. Two places differing in latitude and longitude being given, to find their distance.

The Rule 1. Take their difference of latitude from the equator.

2. Lay a rule on both given places, apply that distance so to the ruler's edge, that when one foot is placed close to the ruler, and the other turned about, it may just touch some east and west line, crossed by the said ruler's edge, there stay the compasses.

3. Then the distance (by the ruler's edge) from the place where the compasses rested to that place where the ruller crosseth the aforesaid east and west line, measured on the equator, giveth the distance required.

Example.

Example.

I demand the distance from the Lizard to the island Barbadoes;

The Lizard's latitude is —	—50d. 00m.	by Prob. 1.
And Barbadoes latitude is —	—13d. 00m.	
Their difference of latitude	37d. 00m.	

Then take their difference of latitude 37 deg. from the equator, and laying a ruler on both places, apply one foot of the compasses so to the ruler's edge, that turning the other about, it toucheth an east and west line, crossed by the ruler; then the distance (by the ruler's edge) from the place where the compasses rested to the place where the ruler crosseth the aforesaid east and west line, measured on the equator is 56d. 40m. or 1133 leagues, the distance required.

And here observe; the meridian line, and line of equal parts next one another on the Gunter; the first is, or may be the meridian, and degrees of latitude in a Mercator's chart; the latter, the equator line and degrees of longitude.

Thus much for the use of Mercator's chart, problems of sailing by it are next; but first some preparatory problems in Geography.

Section 2. Some necessary geographical problems useful in Mercator's-Sailing.

These problems properly belong to Geography, but are necessary in sailing by Mr. Wright's (commonly called Mercator's) chart, and for that reason are placed here.

Note; That all the places mentioned in this book, their latitudes and longitudes, were taken from a chart, intituled, A new and exact Chart, containing the Sea-Coast of Europe, Africa, and America; from England to Cape Bona Esperance, and from New-found-land to the straits of Magellan, according to Mr. Edward Wright's projection, and published by J. Thornton, W. Fisher, J. Seller, J. Colson, and James Atkinson.

This chart has been new made and lately corrected, wherein the longitude of places is reckoned from the meridian of London, agreeing with the Mariner's Compass rectified: as for the disagreement that may be found between it and tables of latitude and longitude in other books, 'tis not to be regarded: because the tables themselves considerably differ from one another; as may appear by the following problems.

Problem 1. The latitude of two places given; to find their difference of latitude.

Rule 1. If the two places are upon the ſame ſide of the equator, that is, both in north latitude, or both in ſouth latitude; ſubtract the leſſer latitude from the greater, the remainder is the difference of latitude.

Rule 2. If one place be on one ſide of the equator, and the other place on t'other ſide; that is, one place in north latitude, the other in ſouth; add the two latitudes together, and the ſum is the difference of latitude.

Obſerve, 1. If a ſhip ſails from a greater north latitude to a leſſer, ſhe ſails ſoutherly; and if a ſhip ſails from a leſs north latitude to a greater, ſhe ſails northerly, which is called raiſing the pole.

2. If a ſhip ſails from a great ſouth latitude to a leſſer, ſhe ſails northerly; but if ſhe ſails from a leſs ſouth latitude to a greater, ſhe ſails ſoutherly.

3. When a ſhip croſſes the equator, and ſails from north latitude into ſouth, the difference of latitude is ſoutherly; or if ſhe ſails from ſouth latitude into north, ſhe ſails northerly.

Example 1. I demand the difference of latitude between the Lizard and iſland of Barbadoes.

The Lizard	latitude	——50d. 00m.	north.
I. Barbadoes		——13d. 25m.	

Their difference of latitude by ſubtraction 36d. 35m. equal to 2195 minutes.

Example 2. To find the difference of latitude between iſland Barbadoes and iſland St. Hellena.

Iſland	Barbadoes	in latitude	——13d. 25m.	north
	St. Hellena		——16d. 00m.	ſouth

Their difference of latitude by adding, is 29d. 25m. equal to 1765 minutes.

Problem 2. The latitude of one place, and the difference of latitude between that and another place being given; to find the latitude of the latter place.

The Rule.

The latitude, and difference of latitude given, being of { One / a contrary } name, their { ſum / diff. } is the latitude required.

Or thus in two rules

Rule 1. In { north / ſouth } lat. ſailing to the { north / ſouth } ward, add the

the difference of latitude to the given latitude, the sum is the latitude required, of the same name.

Rule 2. In { north / south } lat. sailing to the { south / north } ward, { subtract } the lesser from the greater, the remainder is the required latitude, of the same name that the greater is.

Example 1. Sailing from the island Barbadoes north eastward, until the difference of latitude be 372 leagues; what latitude is the ship in?

I. Barbadoes latitude is ——————— 13d. 25m. north
The difference of lat. 372 leag. or 18d. 36m. northerly

Add, is the latitude the ship is in — 31d. 61m. northerly.

Example 2. From the Lizard, a ship sails southwestward, until the difference of latitude be 137 leagues; what latitude is the ship in?

The Lizard latitude is ——————— 50d. 00m. north
The difference of latitude 137 leag. 6d. 51m. southerly

The lat. the ship is in by sub. is 43d. 09m. north

Example 3. From St. Hellena a ship sails northwestwards, until the difference of latitude be 419 leagues; what latitude is the ship in?

I. St. Hellena latitude is ——————— 16d. 00m. south
The difference of lat. 419 leag. or 20d. 57m. northerly

Latitude the ship is in ——————— 4d. 57m. north.

Problem 3. The longitude of two places given; to find their difference of longitude.

1. According to the old way of counting the longitude, the Rule is thus;

Subtract the lesser longitude from the greater, the remainder (if less than 180 degrees) is the difference of longitude; but if the remainder be more than 180 degrees, subtract it from 360 degrees, the last remainder is the difference of longitude.

2 According to the new way of counting the longitude in the Mariner's Compass rectified. The Rule is thus;

If both longitudes be east, or both west, subtract the lesser from the greater, the remainder is the difference of longitude; but if one be east, and the other west, add them together, and the sum (if it exceeds not 180 degrees) is the difference of longitude; and when the sum doth exceed 180 degrees, subtract it from 360 degrees, the remainder is the difference of longitude required.

Example 1. I demand the difference of longitude between the Lizard and island Teneriffa, one of the Canary islands.

		d.	m.
According to the old account, long. of	Lizard is— —	9	42
	I. Teneriffa	0	00
The difference of longitude by subtraction is	—	9	42
According to the Mariner's Compass longitude of	Lizard is	5	24 W
	I. Teneriffa	17	05 W
Their difference of longitude by subtraction is		11	41

The difference of longitude between these two places, are very different in several books, therefore all in this book are taken from the Chart aforesaid, or from the Mariner's Compass rectified.

Example 2. What's the difference of longitude between the Lizard and island Barbadoes?

By the Mariner's Compass, longitude of	Lizard —	—5d. 24m. W
	I. Barbadoes	— 53d. 04m. W
Subtract, is the difference of longitude		47d. 40m.

equal to 2860 minutes.

Problem 4. To know when the difference of longitude between any two places, is easterly, or westerly.

ACcording to the old way of counting the longitude, the rule is thus;

If the remainder (first found) be less than 180 degrees, and you are bound to that place which hath (of the two) the greater longitude, then is the difference of longitude easterly; but if you are to sail to the lesser, it's westerly; and when the first remainder is more than 180 degrees, it's just the contrary.

2. According to the Mariner's Compass rectified, the rule is thus;

When the longitude of the two places are both east or both west, and you are to sail to the greatest longitude; then the difference of longitude is (according to the name of the longitude) east or west, but if bound to the lesser longitude, then is the difference of longitude contrary, that is west in east longitude, and east in west longitude: and if one place lies in east longitude, and t'other in west, the difference of longitude between them, is according to the name of that longitude you are bound unto, that is, east, if to east longitude; and west, if to west longitude.

Problem 5. The longitude of one place, and the difference of longitude between that and another place, being given; to find the longitude of the last place.

1. ACcording to the old way of counting the longitude, the rules are these following.

Rule

Rule 1. Sailing to the eastward, add the longitude and the difference of longitude together, the sum, (but if it exceeds 360 degrees, subtract 360 degrees therefrom, the remainder) is the longitude of the last place.

Rule 2, Sailing to the Westward, subtract the difference of longitude from (but if the difference of longitude be the greatest, add 360 degrees to) the longitude of the first place, the remainder is the longitude required.

2dly, According to the new way of counting the longitude in the Mariner's Compass, the rules are these.

Rule 1. In East Longitude sailing to the Eastward, and in West longitude, sailing Westerly: add, gives the longitude of the last place (if it exceeds not 180 degrees) agreeing with the name of the first place; but if it does exceed, subtract it from 360 degrees, the remainder is the longitude required of a contrary name to the first.

Rule 2. In East longitude saileth Westerly, and in West Longitude saileth Easterly: subtract, gives the longitude of the last place, whose name agrees with the greatest.

Example 1. Sailing from Barbadoes north-easterly, till the difference of longitude be 275 leagues, what longitude is the ship in?

	d. m.
By the Mariner's Compass, long. of the I. Barbadoes is	58 04 W
The difference of longitude is 275 leagues or —	13 45 E
Subtract, gives the longitude the ship is in —	44 19 W

Example 2. From the Lizard a ship sails south westerly, till the difference of longitude be 352 leag. What longitude is the ship in?

	d. m.
By the Mariner's Compass longitude of the Lizard is	5 24 W
The difference of longitude is 352 leagues — —	17 36 W
Add, gives the longitude the ship is in — —	22 60 W

Thus much for the preparation to Sailing by this Chart, the Problems are next.

Sect. III. Containing problems of sailing by Mr. Wright's Chart, commonly called Mercator's sailing.

IN the working of these problems, a Table of Meridional Parts is necessary; accordingly out of Mr. Wright's Table, have I drawn one to every fifth minute of latitude, counting the Meridional Parts in miles, or minutes of the equator; which table you will find placed before the Table of Logarithms, whose use is to find the Meridional difference of Latitude, between any two given latitudes, and that is done by the next problem.

Problem 1. To find the meridional difference of latitude, or the difference of latitude in meridional parts.

The rule is;

The latitude of $\left\{\begin{array}{l}\text{one} \text{———} \\ \text{a contrary}\end{array}\right\}$ name, the $\left\{\begin{array}{l}\text{diff.} \\ \text{sum}\end{array}\right\}$ of the meridional parts (found by the table of meridional parts) answering to the degrees and minutes of each places latitude, is the meridional difference of latitude required.

Exam. 1. Isl. Barbadoes and St. Thome, an island on the coast of Gabon in Africa: what is the meridional difference of latitude?

					minutes
Island	Barbadoes	latit.	13d. 25m. N	mer. pts.	812
	St. Thome		00d. 00m.		000

Meridional difference of latitude ———————— 812

Example 2. The Lizard and island Barbadoes; what is their meridional difference of latitude?

				minutes
Lizard	latitude	50d. 00m.	N. merid. parts	3474
I. Barbadoes		13d. 25m.		812

Subtract, gives the meridional difference latitude ——— 2662

Example 3. Island Barbadoes and island St. Hellena: what is their meridional difference of latitude?

					minutes
Isl.	Barbadoes	lat.	13d. 25m. N.	merid. parts	812
	St. Hellena		16d. 00m. S.		973

Add, gives the meridional difference of latitude———— 1785

Problem 2. The latitude and longitude of two places given; to find their course and distance.

Example. What is the course and distance from the Lizard to the island Barbadoes.

		d. m.		min.		d. m.
Lizard	lat.	50.00N	mer. pts.	3474	lon.	5.24W
I. Barba.		13.25N		812		58.04W

Diff. of lat. 36.35S. mer. diff. lat. 2662 diff. lon. 52. 40 W.

60 60

or 2195 min. or 3160 min.

This

This rectangle triangle ABC (Plate 3. Fig. 5.) is made by problem 13. of Practical Geometry, after this manner.

1. From A representing the place failed from, lay the meridional difference of latitude to B.

2. Draw BC perpendicular to AB, and thereon lay the difference of longitude from B to C.

3. From A to C (representing the place the ship is come to) draw a line, which concludes the triangle ABC, right-angled at B, whose angle BAC measured on the scale of chords or rumbs, shews the course of bearing of the two places.

4. Take the difference of latitude, and lay it on the meridian from A to D, and draw the line DE, parallel to BC, to cut AC in E, and it's done: For if AE be measured on the same scale AD was taken from, it sheweth the distance between the two places.

But to resolve it by Trigonometry, there are two rectangle triangles, ABC, and ADE; in the former you must;

Note, 1. The leg AB, is the meridional difference of latitude.

2. The leg BC, is the difference of longitude.
3. The angle BAC, is the course or bearing.
4. The angle ACB, is the complement of the course.

Secondly, And in the rectangle triangle ADE.
1. The leg AD is the proper difference of latitude.
2. The hypotenuse AE, is the distance of the two places.
3. The leg DE, is the departure from the meridian.
4. The angle DAE, is the course or bearing.
5. The angle AED, the complement of the course.

These things being premised, the proportions are the same as in the Doctrine of plain Right-Angle Triangles, as followeth:

1. For the course, the proportion is thus:

If the leg AB is made radius, then the leg BC is the tangent of the angle BAC, and therefore it is,

As the meridional difference of latitude, is to the radius; so is the difference of longitude, to the tangent of the course: but more briefly thus;

Merid. diff. lat. ·· diff. long. :: radius ·· T. of the course

2662 minutes ·· 3160 min. :: T. 45d. ·· T. 49d. 50m.

Which being turned into points of the compass, makes the course to be SW. $\frac{1}{2}$ W. nearly.

2. To find the distance the proportion is thus:

Making then hypotenuse AE radius, the leg AD is the sine of the angle AED, or the sine complement of the course, and therefore it is

As the sine complement of the course, is to the proper difference of latitude; so is the radius, to the distance in the rumb. Or more briefly thus;

S. c. course ·· diff. lat. :: radius ·· distance required.

S. 40d. 10m. ·· 2195 min. :: S. 90d. ·· 3417 minutes,

Note, The meridional difference of latitude may be found by the Gunter's Scale thus:

Extend the compasses from the latitude of 50d. 00m. (on the meridional-line) to the latitude 13d. 35m. on the same line; that extent measured on the Line of Equal Parts, will be 44$\frac{4}{10}$m. or 2664 minutes, the meridional difference of latitude, which is but 2 minutes more than by the table.

Problem 3. Both latitudes and course given; to find the distance and difference of longitude.

Example. A ship sails from the Lizard, and makes her course (when variation, lee-way, &c. allowed for) to be S. 39d. W. or S. W. by S. ½ W. and then by observation, is in latitude 45d. 31m. north; I demand the distance run, and the longitude she is in?

		d.	m.		minutes
Lizard	latitude	50	00N	meridional parts	3474
Observed	latitude	45	31N	meridional parts	3074
Difference of lat.		4	29	mer. diff. lat.	400
		60			
Or		269 minutes.			

To delineate this, or any of the seven next problems, by the plain scale, as also their resolutions by trigonometry, the directions and notes in the foregoing problems may be sufficient instructions, and therefore they are omitted till I come to problem 10.

1. To find the distance, the proportion (as in Plain-Sailing) is thus;

S. c. course ·· diff. lat. :: radius ·· distance required.

S. 51d. 00m. ·· 269 min. :: S. 90d. ·· 346 minutes.

2. To find the difference of longitude the proportion is thus;

Radius ·· T. course :: meridi. diff. lat. ·· diff of longit.

T. 45d. ·· T. 39 deg. :: 400 minutes ·· 325 min. or 5° 25′

Or thus; the extent on the meridional line (on the Gunter) from latitude 50d. 00m. to latitude 45d. 31m. measured on the Line of Equal Parts, in 6d. $\frac{7}{10}$m. the meridional difference of latitude; and then you may say.

T. 45d. ·· T. 39d. :: 6d. $\frac{7}{10}$ ·· 5d. $\frac{4}{10}$ or 5d. 24m. the difference of longitude near as above.

3. Then

2. Then to find the longitude the ship is in, it's thus,

Longitude sailed from	— — —	5d. 24m.	West.
Difference of longitude 345 minutes or	—	5d. 25m.	West.
Longitude the ship is in	— —	10d. 49m.	West.

Problem 4. Both latitudes and distance given; to find the course, and difference of longitude.

Example. If a ship runneth 300 minutes north westward from a port in latitude 37d. N. and longitude 10d. 25m. W. until she be in latitude 41d. north: I demand the course and longitude she is in?

				min.
Sailed from	latitude	37d. north	merid. parts	2393
Ship is in	latitude	41d. north	merid. parts	2702
Difference of latitude		4 north.	Merid. diff. latit.	309
		60		
		Or 240 minutes.		

1. To find the course, the proportion (as in plain Sailing) is thus;
Difference ∵ radius :: diff. lat. ∵ Sc. course.
300 min. ∵ S. 90d. :: 240 min. ∵ S. 53d. 00m. which
subtract from — — — 90d. 00m. north

Remainder is the course — — 36d. 52m. north

Westerly $3\frac{1}{4}$ points of the compass, which makes the course to be N. W. by N $\frac{1}{4}$ W. nearest.

2. To find the diff. of longitude, the proportion is thus; Radius ∵ T. course :: merid. diff. lat. difference long. T 45d. ∵ T. 36d. 52m. :: 309 minutes ∵ 232 min. or 3d. 52m:

Or thus, the extent (on the Meridional Line on the Gunter) from latitude 37d, to latitude 41d. measured on Equal Parts, is 5d. 10m. meridional difference of latitude. And then say, T. 45d. ∵ T. 36d. 52m. :: 5d. $\frac{17}{100}$ 3d. 88 parts of 100, or 3d. 52m. the difference of longitude as before.

Longitude sailed from	— — —	10d. 25m.	west.
Difference of longitude is 232 minutes	or	3d. 52m.	west.
Longitude the ship is in	— —	14d. 17m.	west.

Problem 5. Both latitudes and departure from the meridian given; to find the course, distance and difference of longitude.

Example. A ship in latitude 50d. 10m. north, and longitude 5d. 24m. west, sails south westward, till her departure is 789 minutes, and by observation is in latitude 39d. 20m. north: I demand the course, distance sailed, and what longitude the ship is in;

The

The proportion for the course and distance are the same as in Chapter 3. Section 3. Case 6. of Plain Sailing, in Page 60, to which I refer you, and here omit them.

3. To find the difference of longitude the proportion is;

Lat. { departed 50d. 10m. N / ship is in 39d. 20m. N } Meridional Parts { 2490 / 3571 } min.

Difference of lat. 10d. 50m. S. Merid. diff. lat. 919 min.
60

Difference lat. 650 minutes. Then you may say,

As diff. lat. ∙∙ departure :: merid. diff. lat. ∙∙ difference of long.

As 650 min. ∙∙ 789 min. :: 919 minutes ∙∙ 1116m. or 18d. 36m.

Or thus; the extent (on the meridional-line on the Gunter) from latitude 50d. 10m. to latitude 39d. 20m. measured on the line of equal parts, is 15d. 3 tenths the meridional difference of latitude. And then say,

As 650 minutes ∙∙ 789 min. :: 15d. 3 tenths ∙∙ 18d. 6 tenths or 18d. 36m. the difference of longitude as before.

Then to find the longitude the ship is in it's thus,

Longitude sailed from ——————— 5d. 24m. west
Difference of longitude 1116 min. or ——— 18d. 36m. west
Longitude the ship is in ——————— 24d. 00m. west

Problem 6. One latitude, course and distance given, to find the difference of latitude, and difference of longitude.

Example. A ship in latitude 42d. 30m. north and longitude 18d. 31m. west, sails SE by S, 599 min. or 187 leagues: I demand the latitude and longitude the ship is in?

1. For the difference of latitude, the proportion (by the 1*st*) case of Plain Sailing in Page 59, is thus;

As radius ∙∙ distance :: Sc. course ∙∙ difference of latitude.

As S. 8 points ∙∙ 591 min. :: S. 5 pts. ∙∙ 491 min, or 8d. 11m.

Latitude sailed from—42d. 30m. N. merid. parts 2822m.
Diff. lat. 491 min. or 8d. 11m. S.
Latitude the ship is in 34d. 19m. N. merid. parts — 2195m.
Subtract giveth the meridional difference of latitude — 027m.

Or thus; the extent (on the meridional-line on the Gunter) from latitude 42d. 30m. to latitude 34d. 19m. measured on the line of equal parts is 10d. $\frac{5}{10}$ or 10d. 30m. the meridional difference of latitude.

To find the difference of longitude, the proportion is,

As radius ∙∙ T. course :: merid. diff. lat. ∙∙ difference long.

As

As T. 4 pts ·· T. 3 points. :: 627 minutes ·· 420. or 7d. 00m.

Or thus;

As T. 4 points ·· T. 3 pts. :: 10d. $\frac{5}{10}$ 7d. diff. long, as before.

Longitude sailed from ——— ——— ———	18d. 31m. west
Diff. long. 420 minutes, or ——— ——— ———	07d. 00m. east
Longitude the ship is in ——— ——— ———	11d. 31m. west

Problem 7. One latitude, course, and departure given, to find the distance, difference of latitude, and difference of longitude.

Example. A ship sails ESE, from a certain port in latitude 50d. 10m. south, and longitude 10d. 16m. east, until the departure from the meridian be 957 minutes: I demand her distance sailed, the latitude and longitude she is in?

The distance is 1035 }
The diff. of lat. is 396 } min. by chapter 2. section 3. problem 3.

of Plain Sailing, in page 58. Then the latitude the ship is in, and the meridional difference of latitude, is found thus. Min.

latitude sailed from 50d. 10m. south merid. parts———	3490
Diff. latitude 396m. or 6d. 36m. S.	
Latitude ship is in——56d. 46m. S. meridional parts	4157
Subtract, giveth the meridional difference of latitude———	667

For the difference of longitude the proportion is;

As diff. lat. ·· departure :: merid. diff. lat. ·· diff. of long.

As 396 min. ·· 957 min. :: 667 minutes ·· 1615m. or 26d. 55m.

Or thus; the extent (on the meridional line on the Gunter) from latitude 50d. 12m. to latitude 56d. 46m. measured on the line of the Equal Parts; its 11d. $\frac{5}{10}$ the merid. diff. of lat.

Then say,

As 396 min. ·· 957 min. :: 11d. $\frac{1}{18}$ ·· 27d. the diff. long.

Then to find the longitude the ship is in, it's thus;

Longitude sailed from——— ———	10d. 16m. east
Difference of longitude 1615 min. or ———	26d. 55m. east
Longitude the ship is in——— ——— ———	37d. 11m. east

Problem 8. One latitude, distance sailed, and departure from the meridian given; to find the course, difference of latitude, and difference of longitude.

Example. A ship in latitude 49d. 30m. north, and longitude 14d. 40m. west, sails south eastward 645 minutes until the departure from the meridian be 500 minutes: I demand the course steered, the latitude and longitude the ship is in?

1. The course is 50d. 50m. SE. or SE$\frac{1}{2}$E. }
2. The diff. of lat. 407 min. or 6d. 47m. } by chap. 3.

section

ſection 3. problem 5. of Plain Sailing in page 95. Then the Latitude the ſhip is in, and the Meridional difference of Latitude is found thus; min.

Latitude ſailed from—49d. 30m. N. merid. parts 3428
Diff. lat. 407 min. or— 6d. 47m. S.
Latitude the ſhip is in 42d. 43m. N. merid. parts 2840
Meridional difference of latitude ——— ——— ——— 588

3. To find the difference of longitude the proportion is;
As diff. lat. ·· depart. :: merid. diff. lat. ·· diff. of long.
As 407 min. ·· 500 min. :: 588 minutes ·· 722 min. or 12d. 2m.

Or thus, the extent (on the meridional line on the Gunter) from latitude 49d. 30m. to latitude 42d. 43m. meaſured on equal parts, is 9d. $\frac{8}{10}$, the meridional difference of latitude.
Then ſay,

As 407 min. ·· 500 min. :: 9d. $\frac{8}{10}$ ·· 12d. the diff. long.

Then to find the longitude the ſhip is in, it's thus;
Longitude ſailed from——— ——— ——— ———14d. 40m. weſt
Diff. longitude 722 minutes, or ——— ———12d. 02m. eaſt
Longitude the ſhip is in——— ——— ——— ——— 2d. 38m. weſt

Problem 9. One latitude, courſe, and difference of longitude given; to find the diſtance, and difference of latitude

Example. A ſhip ſails SW by W. from the Lizard, until ſhe be in longitude 57d. 26m. weſt: I demand the latitude the ſhip is in, and her diſtance ſailed?

Longitude ſailed from——— ——— ——— ———5d. 24m. weſt
Longitude the ſhip is in——— ——— ———57d. 26m. weſt
Subtract, and remainder is the diff. longit. — 52d. 02m. weſt
60
Or 3122 minutes

1. For the mer. diff. of lat. the proportion may be thus;
As T courſe ·· radius :: differ. lon. ·· merid. diff. of lat.
As T. 5 pts. ·· T. 4 pts. :: 3122 min. ·· 2085 minutes.
Latitude ſailed from 50d. its merid. parts—2474 ſubtract.
Giveth the mer. pts. for the lat. the ſhip is in 1389 which ſeek in the table of Meridional Parts; againſt it you will find 22d. 33m. the latitude the ſhip is in north.

Or thus, on the Gunter; take the meridional difference of latitude, being 2085 minutes, or 34d. 45m. from the line of equal parts, and ſet it from the latitude departed from; being 50d. 00m. in the meridional line, decreaſing (becauſe its north latitude and ſailing ſoutherly (and it reacheth) in the ſame line) to 22d. 30m. the latitude the ſhip is in, very near to the latitude found about by the table of meridional parts, differing from it but 3 minutes.

Then having both latitudes known, the difference of latitude is found (by ſubtracting the leſſer from the greater) to be 27d. 27m. or 1647 minutes, or 549 leagues.

2. Find

2. Find the distance sailed by chapter 3. sect. 3. problem or case 2. of Plain Sailing, in page 53.

Problem 10. Two places in one parallel or latitude, their difference of longitude given; to find their distance.

Example. I demand the distance between the Lizard and Pengwin island on Newfound-land.

Pengwin island	longit. is	53d. 10m. west
Lizard —		5d. 24m. west

Subtract, and remainder is diff. long.———— 47d. 46m. west
60

Difference of long. 47. 46m. or———————— 2866 minutes.

These places are both (supposed to be) in latitude 50d. 00m. north, whose complement is 40d. 00m.

To delineate this problem by the Plain Scale.

1. Draw the pricked arch BC, with the sine of 90 degrees, one foot being in the center A.

2. Lay the difference of longitude on that arch from B to C and draw the lines AB, AC, and BC.

3. With the sine complement of the latitude, and one foot in A, draw the arch DE: that is take the complement of the latitude from the sines, and with one foot on A, draw the pricked arch DE, to cut AB in D, and AC in E.

4. Draw a line from D to E. and it's done; for DE being measured on the same scale BC was taken from, will shew the distance required.

The explanation of the scheme

1 A represents one of the poles of the earth,
2 The arch BC, is the equator.
3 The arch DE, is a parallel of latitude.
4 The line ADB, is the meridian of the Lizard.

5. The

5 The line AEC, is the meridian of Pengwin island.
6 D is the Lizard. } in the latitude of 50d. 00m.
7 E is Pengwin island. }
8 The line BC, is the difference of longitude.
9 The line DE is their distance in that parallel of latitude.

Then to find their distance, the proportion is by the 4th proposition of the 6th book of Euclid.

As AB, is to BC, so is AD, to DE. And alternately.

As AB is to AD: so is BC, to DE. That is,

As radius is to the sine complement of the latitude; so is the difference of longitude, to the distance in that parallel of latitude. In short thus,

As radius ·· Sc. latitude :: diff. lon. ·· dist.

As S 90d ·· S. 40d. 00m. :: 2866 min. ·· 1842 minutes.

Or thus; by the Plain Scale.

Take the latitude of 50d. 00m. from the Scale of Chords, and measure it from 60 on the Scale of Longitude marked (ML) and it sheweth minutes 38.6 tenths make a degree of longitude in that latitude: then say,

As 1 deg. ·· min. 38.6 :: diff. lon. 47d. $\frac{76}{100}$ ·· 1842 minutes the distance as before.

Problem 11. Two places in one latitude, their distance given; to find their difference of longitude.

Example. If a ship sails west 390 minutes from the Lizard; what longitude is she in?

To delineate the problem by the Plain Scale.

1. Take 90 degrees from the Scale of Sines, and with one foot on A, draw the pricked arch BC.

2. From the Scale of Sines take the complement of the given latitude, and setting one foot on A, draw the pricked arch DE.

3. Then from any Scale of equal Parts, take (the distance run) and lay it on the last arch from D to E.

4. From A draw lines through D and E, to cut the arch BC, in B, and in C.

5. Then draw a line from B to C, and it's done; for BC being measured on the same scale DE was taken from, will shew the difference of longitude required.

The proportion (by the 4th proposition of the 6th book of Euclid) for the difference of longitude is,

As Sc. latitude ·· radius :: distance ·· difference of longit.

As S. 40d. 00. ·· S. 90d. :: 390 min. ·· 607 min. or 10d. 07m.

Or

Or thus; by the Plain Scale.

The latitude 50d. 00m. (taken from the Chords) and measured on the scale ML, sheweth minutes 38.6 tenths make a degree of longitude in that latitude: then say,

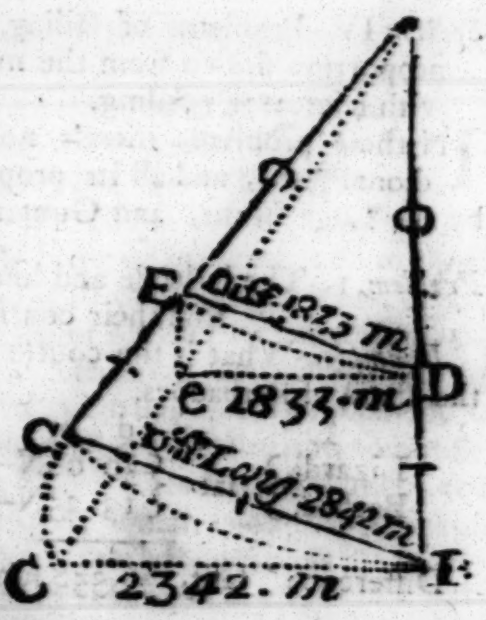
As min. 38.6 tenths ∙∙ 1d. :: 390m. ∙∙ 10d. $\frac{1}{10}$ or 10d. 06m. diff. long. differing but one minute from that found before.

Latitude of the Lizard	— —	—05d. 24m. west
Difference of longitude 607 minutes, or	—	—10d. 07m. west
And gives the longitude the ship is in	—	— 15d. 31m. west

Problem 12. Two places in one parallel or latitude, their distance, and difference of longitude given, to find the parallel of latitude.

Example. Suppose two ships in the equator 2842 minutes asunder, and they both sail north alike distance, till they are but 1833 minutes asunder: I demand what latitude they are now in?

To delineate this Problem by the Plain Scale.



1. Draw the pricked arch BC from the sine of 90 degrees, one foot being on the center A, to cut the line AB in B.
2. On B erect the pricked perpendicular Bc, and thereon lay the difference of longitude from B to c.
3. Draw the pricked line Ac.
4. Then with the distance in the parallel, and one foot in the pricked line Ac, moved upon that line, till the other foot turned about, will but just touch the line AB, and where the former foot resteth which is at e, there stay it.
5. Take the nearest distance from e, to the pricked line Bc, and lay that distance on the line AB, from B to D, and draw the pricked line De.
6. Lay the difference of longitude on the pricked arch made with the sine of 90 degrees, from B to C, and draw the line AC;

AC; also with the distance AD, and one foot on A, draw the pricked arch DE to cut AC in E; likewise draw lines from B to C, and from D to E, and it's done; for AD or AE measured on the scale of Sines, will shew the complement of the latitude required.

Note, If Bc, be equal to BC, and De equal to DE, it's done true, otherwise not; as the pricked arches c C and e E manifesteth.

To find the latitude (by the foresaid proposition of Euclid) the proportion is thus;

As differ. lon. ∙∙ distance :: radius ∙∙ S. c. latit. required.
As 2842 min. ∙∙ 1833 min :: S. 90 ∙∙ S. 40d. 10m.
Which subtracted from — — 90d. 00m.

The remainder is the parallel of latitude 49d. 50m. north.

Or thus, by the Plain Scale.

As 2842 min. ∙∙ 1833 min. :: 60 min. ∙∙ min. 38.7 tenths making one degree of longitude, is the latitude required.

Then from the Scale of Longitude (marked ML) take min. 38.7 tenths, measure it on the Scale of Chords, and it sheweth the latitude to be 49d. 50m. as before.

Section IV. Problems of sailing by the middle latitude; or a proportion drawn from the middle latitude, nearly agreeing with Mercator's sailing.

IN these problems there's no use made of the table of meridional parts, and all its proportions may be wrought both by the Logarithms, and Gunter's Scale.

Problem 1. The latitude and longitude of two places given? to find their course and distance.

Example. What is the course and distance from the Lizard to the island of Barbadoes.

		d m	d m		d m
Lizard.	lat.	50 00N	50 00	long.	5 24 W.
Barbad.		13 25N	13 25		58 04 W.
Difference	latit.	36,35S.	sum lat. 63,25	diff. long.	52 40 W.
		60	mid. lat. 31 42		60
		Minutes 2195	sub. it from 90 00	or	3160 min.
			Com. mid. lat. 58 18		

To

To delineate the Problem by the plain ſcale plate 2. fig. 6.

1. Make AD upon the meridian equal to the difference of latitude.

2. Draw the pricked arch IK with the ſine of 90 degrees (one foot being on A) to cut the meridian AD in I.

3. With the ſine complement of the middle latitude and one foot on A, draw the pricked arch GH, to cut the meridian in G.

4. On the laſt arch, lay ½ the difference of latitude, from G to H.

5. By A and H draw a line, to cut the firſt arch (made with the ſine of 90 degrees) in K.

6. Lay IK twice on the meridian, from A to B.

7. On B erect a perpendicular, and thereon lay the difference of longitude, from B to C.

8. Draw a line from A to C; and from D, draw DE parallel to BC, to cut AC in C, and it's done. Plate 3. fig. 6.

Then is the leg AD the difference of latitude.
Leg BC the difference of longitude.
Hypot. AE the diſtance of the two places.
Leg DE the departure, according to the Plain Chart.
Angle DAE, or BAC the angle of the courſe or bearing.
Angle AED the complement of the courſe.

1. To find the courſe, or bearing, the proportion is;

As the difference of latitude, is to the difference of longitude; ſo is the ſine complement of the middle latitude, to the tangent of the courſe. Or more briefly thus,

As diff. lat. ·· diff. long. :: Sc. middle lat. ·· T. courſe.
As 2195 min. ·· 3160 min. :: S. 58d. 18m. ·· T. 50d. 45m.

By Gunter. The extent from 2195 minutes to 3160 minutes on Numbers, being laid (increaſing) from ſine 58d. 18m. reacheth beyond the ſine of 90d. wherefore lay that extent from the ſine of 90 degrees towards the left-hand, and ſtay one foot there, then bring in the other foot to the ſine complement of the middle latitude 58d. 18m. this laſt diſtance of the compaſſes lay from tangent of 45 degrees, and it ſheweth on tangent 50d. 45m. the courſe of SW½W. neareſt, which is the courſe from the Lizard to Barbadoes.

Or thus; by two proportions to find the courſe.

Firſt, As the radius is to the ſine complement of the middle latitude; ſo is the difference of longitude to the departure from the meridian, or meridional diſtance. More briefly thus;

As radius ·· Sc. middle lat. :: diff. long. ·· departure.
As S. 90d. ·· S. 58d. 18m. :: 3160 min. ·· 2685 min.

Secondly, As the difference of latitude, is to the departure from the meridian; so is radius, to the tangent of the course. Or more briefly thus;

As diff. lat. : departure :: radius : T. course.

As 2195 min. : 2685 min. :: T. 45d. : T. 50d. 45m. as before.

2. To find the distance, the proportion is;

As Sc. course : diff. lat. :: radius : distance required.

As S. 39d. 15m. : 2195 min. :: S. 90d. : 3467 minutes.

Problem 2. Both latitudes and course given; to find the distance and difference of latitude.

Example. Suppose a ship sails from the Lizard, and made (when variation Lee-way, &c. allowed for) her course south 39d. west, or SW. by S. $\frac{3}{4}$ W. and then, by observation, is in latitude 45d. 31m. north, what's her distance run, and longitude she is in?

					d.	m.
Lizard } latitude	{ 50d. 00m. north	—	—		50	00
Observed } latitude	{ 54d. 31m. north	—	—		45	31
Difference of latitude	4d. 29m.			Sum both lat.	95	31
	or 60			The $\frac{1}{2}$ is the mid. lat.	47.	45
Diff. lat. is minutes	269			Which subt. from	90	00
The remainder is compl. of the middle latitude			—		42	15

To delineate this or any of the following problems by the Plain Scale, the instructions in the foregoing are sufficient to inform the diligent reader.

1. The distance is 346 minutes by chapter 3. sect. 3. prob. or case 2. of Plain Sailing, in page 58.

2. To find the difference of longitude, the proportion is;

As the sine complement of the Middle Latitude, is to the tangent of the course; so is the Difference of Latitude, to the Difference of longitude. Or thus;

As Sc. Mid. Lat. : T. course :: diff. lat. : difference lon.

As S. 42d. 15m. : T. 39d. :: 269 min. : 324 min.

To work this, or any such like proportion, by Gunter's Scale, the general rule of extending from the first term to the second, &c. will not serve, till the first and second terms are reduced to one Line or Scale, and that is by this rule following.

A general rule to reduce the second Term Tangent, to the first Term Sine.

Extend the compasses from tangent 45d. to the tangent of the second term; lay that extent on the Line of Sines, from 90d. if the second term be less than 45d. but if more, from the first

first term towards the left-hand; and where the foot resteth, I call the second term reduced to the first, and is to be counted instead of the second term. As for example,

To work the foresaid proposition, for to find the difference of longitude.

1. The extent from tangent 45d. to tangent 39d. laid from sine 90d. reacheth to sine 54d. 05m. the second term reduced to the first term.

2. The extent from the sine 54d. 05m. (the second term reduced) to sine 42d. 15m. the first term is the proportion; laid on the line of Numbers from 269 minutes the third term, will reach to 324 minutes the fourth term, the difference of longitude required.

Or thus, by two Operations to find the difference of longitude.

First; As the sine complement of the course, is to the difference of latitude; so is the sine of the course, to the departure from the meridian, or meridian distance. Or thus,

As Sc. course ·· diff. lat. :: S. course ·· departure.

As S. 51 degrees ·· 269 min. :: S. 39 deg. ·· 218 min.

Secondly: As the sine complement of the middle latitude, is to radius; so is the departure from the meridian, to the difference of longitude. Briefly thus;

As Sc. middle lat. ·· radius :: departure ·· diff. longit.

As S. 42d. 15m. ·· S 90d. :: 218 min. ·· 324m. as before.

Then to find the longitude the ship is in, it's thus.

Lizard longitude is ———————	05d. 24m. west
Diff. longitude 324 minutes, or——— ———	05d. 24m. west
Longitude the ship is in ——— ———————	10d. 48m. west

Problem 3. Both latitudes, and distance given; to find the course, and difference of longitude.

Examp. If a ship runneth 300 minutes north westerly, from a port in 37d. north latitude, and longitude 10d. 25m. W. until she be in latitude 41 degrees north. What is her course, and longitude she is in?

Sailed from } latitude {	37d. north	——— ———	37d
Ship is in— } latitude {	41d. north	——— ———	41d.
Difference of latitude —4d. N.	Sum of both latitudes —		78d.
	60 middle latitude	———	39d.
Diff. latitude is minutes 240	Subtract from	———	90d.
Complement of the middle latitude	———	———	51d.

1. The course is north 36 deg. 52 min. W or NW. by N¼W. nearest; found by chap. 3. sect. 3. case 4. of Plain Sailing in page 59.

 2. To

2. To find the difference of longitude, the proportion is thus,
As Sc. middle lat. ·· T. course :: differ. lat. ·· longit.
As S. 51 degrees ·· T. 36d. 52m. :: 240 min. ·· 232 min.

By Gunter's Scale. The extent from tangent 45d. to tangent 36d. 52m. will reach from sine 90d. to sine 48d. 30m. the second term reduced to the first. Then the extent from this last (sine 48d. 30m.) to sine 51d. (the first term in the abovesaid proportion) will reach to the line of Numbers from the difference of latitude 240 minutes, to 232 minutes, or 3d. 52m. the difference of longitude.

Or thus; by two proportions (after the course is found) as before to find the difference of longitude, say,

1. As the radius, is to the distance run; so is the sine of the course, to the departure from the meridian. Which briefly is thus;

As radius ·· distance :: S. course ·· departure.
As S. 90d. ·· 300 min. :: S. 36d. 52m. ·· 180 minutes.

2. As the sine complement or middle latitude is to radius: so is the departure from the meridian, to the difference of longitude. Briefly thus;

As Sc. mid. lat. ·· radius :: departure ·· diff. longitude.
As S. 51. deg. ·· S. 90d. :: 180 min. ·· 232 min.

Or it may be found by this proportion when the distance is given.

Sc. middle lat. ·· distance :: S. course ·· diff. longitude.
S. 51 deg. ·· 300 min. :: S. 36d. 52m. ·· 232 min.

Then to find the longitude the ship is in, it's thus;

Longitude the ship sailed from	10d. 35m.	west
Diff. longitude 232 minutes, or	3d. 52m.	west
Longitude the ship is in	14d. 27m.	west

Problem 4. Both latitudes and departure from the meridian given; to find the course, distance, and difference of longitude.

Example. A ship in latitude 50d. 10m. north and longitude 5d. 24m. west; sails south westerly, till the departure be 789 minutes, and she be in latitude 39d. 20m. north. I demand the course, distance and longitude the ship is in?

Latitude { sailed from	50d. 10m. north	— —	50d. 10m.
Latitude { ship is in	39d. 20m. north	— —	39d. 20m.
Difference of latitude	10d. 50m. S.	Sum of both lat.	89d. 30m.
	60		
Or minutes	650	The ½ is the mid. lat. —	44d. 45m.
		Which subtract from —	90d. 00m
The remainder is complement middle latitude			45d. 15m

The

The course is S. 50d. 30m. W } by chapter 3. section 3.
The distance 1022 minutes } problem or case 6 of Plain Sailing in page 60.

To find the difference of longitude the proportion is;
As Sc. mid. lat. ·· T. course :: diff. lat. .. diff. longit.
As S. 45d. 15m. ·· T. 50d. 30m. :: 650 min. ·· 1111 minutes.

For the extent from tangent 45d, to the tangent 50d. 30m. laid (on the Line of Sines) from 45d. 15m. reacheth to sine 35d. 50m. the second term reduced to the first. Then the extent from this last (sine 35d. 50m. to S. 90d. (instead of sine 45d. 15m. the first term in the above proportion, always so when the course is more then 45d. and that laid on the Line) of Numbers, from diff. lat. 650 minutes, will reach to 1111 minutes, the difference of longitude required.

Or thus; The difference of longitude may be found without knowing the course, saying;

As the sine complement of the middle latitude, is to the radius; so is the departure from the meridian, to the difference of longitude, that is,

As Sc. middle lat. ·· radius :: departure ·· diff. long.
As S. 45d. 15m. ·· S. 90 deg. :: 780 min. ·· 1111 M. as before.

Then the Longitude the ship is in, may be found, as in problem 5. of Mercator's Sailing, page 89, that being the same question with this.

And in like manner all the remaining questions in Mercator, may be wrought by the sine complement of the middle latitude, which I leave to the learner's practice. And thus much may suffice for the Second kind of sailing or Second Part of Navigation. And the application of Plain Trigonometry; Spheric Trigonometry is next.

Chap. V.

Containing the doctrine of spheric triangles, rectangular and oblique, both geometrical and arithmetical.

BEfore I enter on Spheric Trigonometry, as to the framing and working of proportions therein, it will be necessary you should understand how to make a spheric triangle, and to measure any of its parts: in order thereunto, I have contrived the following problems, which I call Spheric Geometry.

Section I. Spheric Geometry *explained by definitions and problems.*

Definition 1. SPheric Geometry, is that by which the circles of the ſphere are deſcribed, drawn or projected on a plain.

2. A Sphere or Globe, is a round body, made by the moving of a ſemi-circle about its own diameter, till the motion ends where it began.

3. A Projection of the Sphere, is either arthographical, Stereographical, or gnomonical.

4. Arthographical, is the drawing the ſuperficies of the ſphere on a plain, which cutteth the ſphere in the middle, with reſpect to the eye being placed perpendicular to it, and at an infinite diſtance therefrom: this projection maketh uſe only of a Scale of Chords, and of Sines.

5. Stereographical, ſheweth how to deſcribe the ſphere's ſuperficies on a plain, which cutteth it in the middle, with reſpect to the eye being placed in the ſphere's ſuperficies, perpendicular to the center of the ſaid plain.

6. Gnomonical projecting the Sphere, is drawing the ſuperficies on a plain touching it, with reſpect to the eye being placed in the ſphere's center.

Theſe two laſt make uſe of a Scale of Chords, Tangents, and Secants.

7. All circles of the ſphere, are either great circles, which cut it in two equal parts; or leſſer circles, which cut it in two unequal parts.

8. The plain on which the ſphere is projected, is that circle which bounds or limits the projection, and is repreſented by the circle ABCDEBA. Plate 3. fig. 7.

9. A Great Circle, is either the primitive circle, a right-circle, or an oblique circle.

Theſe circles conſidered ſeverally, or jointly, afford divers Problems, which are the ſubject-matter of Spheric Geometry, and are ſuch as follows.

Problem 1. *To find the pole of any great circle.*

Definition 1. A Great Circle, is either the primitive circle, as BCDEB; or right circle as the diameter BAD; or an oblique circle, as the arch BFD. Plate 3. fig. 7.

2. The Pole of a Great Circle, is a punct every way 90 degrees diſtant from it. And,

Note, 1. The pole of a Great Circle, is either upon the primitive circle, or within it.

2. When

2. When the pole is within, it's either at the primitive circle's center, or not.

In this problem, are three cases.

Problem 1. case 1. *The pole of the primitive circle is required.*

Example. BCDE. The primitive circle given; to find the pole thereof is required. Plate 3. fig. 7.

The rule. Find A, the center of the primitive circle BCDE, which center A is the pole required.

Problem I. case 2. *The pole of a right circle is required.*

Definition. A Right Circle passeth through a center of the Primitive circle, and in the projection is a diameter; as BAD.

Note, A Right circle hath its pole on the primitive circle.

Example. The pole of the right circle BAD is required. Plate 3. fig. 7.

The rule. From the chords lay 90 degrees on the primitive circle from B or D, both ways to C, or E: I say C, or E, are the poles of the right circle BAD.

Problem I. Case 3. *The pole of an oblique circle is required.*

Definition. An Oblique Circle passeth not through the center of the primitive circle, and in the projection is represented by an arch; as BFD. Plate 3. figure 7.

Note 1. The poles of an oblique circle, is in a diameter which passeth through its center.

1. One of the poles of an oblique circle, lieth between the center of the primitive, and oblique circles.

2. Every great circle, whether right, or oblique, cutteth the primitive, diametrically opposite.

Example.

$$\left.\begin{array}{l}\text{BCDE the primitive}\\ \text{BFD the oblique}\end{array}\right\}\text{ circle and }\left\{\begin{array}{c}\text{A}\\ \text{Y}\end{array}\right\}\text{ its center given.}$$

The pole of an oblique circle BFD *is required. Plate* 3. *fig.* 7.

The rule 1. Through A and Y, draw a diameter, to cut the primitive circle in C and E, and the oblique circle in F.

2. Lay a scale on B and F, to cut the primitive circle in G; which is called reducing F to the primitive circle.

3. Take 90 degrees (from the Scale of Chords) and lay it on the primitive circle, from G both ways to H.

4. Reduce H to the diameter CAE, by laying a Scale on B and H, to cut the diameter CAE, both within the primitive circle, and without either of which points I is the pole of the oblique circle BFD.

Problem 2. *To describe a spheric angle.*

Definition 8. A Spheric Angle, is made by the intersection of two great circles; the intersection being the angular punct.

Note, In this problem are two cases.

Problem 2. Case 1. *To make an angle, that the angular punct may be at the center of the primitive circle.*

The Rule. Such an angle is made (in all respects) like a plain scale.

Example. An angle BAC equal to 40d. 30m. (whose angular punct A may be the center of the primitive circle) is required to be made. Plate 3. fig. 8.

1. With the chord of 60 degrees (on the center A) describe the primitive circle, BCDE.

2. On the primitive circle, and from the same Chords, make BC equal to 40d. 30m.

3. From B and C draw two right circles, or diameters thro' A, which will conclude the angle BAC required to be made.

Problem 2. Case 2. *To make an angle, that the angular punct may be at the primitive circle.*

The Rule. Such an angle is made by drawing an oblique circle with the secant of the given angle.

Example. *An angle EBF equal to 34d. 30m. (whose angular punct B may be at the primitive circle) is required to be made?* Plate 3. fig. 7.

1. Describe the primitive circle BCDE, as before directed.

2. Lay a scale on A the primitive circle's center) and cut the primitive circle in B, and D.

3. With the secant (of the given angle) 34d. 30m. and one foot in B, describe the arch Y.

4. With the same, and one foot in D cross the former arch Y in Y; the center of the oblique circle BFD, which will conclude the angle EBF, equal to EDF, required to be made.

Note, When the given angle is obtuse, subtract it from 180 degrees, and with the remainder make the angle as above directed, and it's done.

Problem 3. *To draw a great circle through any given punct, so that it shall make at the primitive circle any given angle.*

The Rule. 1. With the tangent of the given angle, and one foot in the center of the primitive circle, make an arch.

2. With

2. With the ſecant of the ſame, and one foot in the given punct the former arch, which croſſing, is the center of the circle required to be drawn.

Example. Plate 3. fig. 7.

BCDE the primitive circle }
A the center thereof— — } given :
F the punct———————— }

Through F, to draw an oblique circle, that it may make an angle at the primitive circle, equal to 34d. 30m. is required?

Note: The given point muſt be ſo far from the center of the primitive circle, that the tangent from the center, and the ſecant (of the ſame) from the given punct, may interſect each other; otherwiſe it's impoſſible.

1. With the tang. of 34d. 30m. and one foot in A, make an arch Y.

2. Then with a ſecant of the ſame and foot in F, cut the arch Y in Y; the center of the oblique circle BFD, required to be drawn; and if B, and D, are diametrically oppoſite, it's done true, otherwiſe not.

Prob. 4. *To draw a great circle through any two puncts given, either both within the primitive circle, or one within, and the other without.*

The Rule. 1. Draw a line from the primitive circle's center, through one (always the remoteſt) of the two puncts, to cut the primitive circle and produce it at pleaſure.

2. From the ſaid punct draw another line to a punct in the primitive circle, that is 90d. diſtance from the firſt line.

3. On this laſt line, and at the punct in the primitive circle, erect a perpendicular, to cut the firſt line in the third punct.

4. Through the two given puncts, and this laſt third point draw (by chap. 1. ſect. 2. prob. 7. of Practical Geometry, in page 15) an arch of an circle, and it's done.

Example. Plate 3. fig. 9.

BCDE the primitive circle }
A the center thereof — — } given :
F and G two puncts — — }

Through F and G it's required to draw a great circle?

1. Through A and F draw the Right Circle BFAD, to cut the primitive circle in B and D, and continue it further at pleaſure.

2. Lay the chord of 90d. on the primitive circle from B. or from D to E or C, and draw the line FE, or FC.

3. At E erect EH perpendicular to EF, or (erect CH perpendicular to CF to cut the diameter BFAD, in H the third punct

4. Through

4. Through F G and H, draw a circle as IFGKH, which cuts the primitive circle in I and K, diametrically opposite, and it's done.

Prob. 5. *To draw a great circle perpendicular to, or at right angles, with a given great circle.*

A general rule. Draw a great circle through the pole of the given great circle, and its perpendicular to it, or it makes a right angle with it.

Note, In this problem are four cases.

Prob. 5. Case 1. *To draw a circle perpendicular to the primitive circle.*

The Rule. This is done by drawing a diameter through the center of the primitive circle; for the center of the primitive circle, being its pole; all right lines drawn through the center, are perpendicular circles to the primitive circle.

Example. Plate 3. fig. 7.

BCDE the primitive circle, and A its center given; to draw a great circle perpendicular to it is required.

Through A draw the right circle BAD and its perpendicular to the primitive circle BCDE, as was required.

Prob. 5. Case 2. *To draw a right circle perpendicular to a given right circle.*

The rule. This is done by drawing a diameter at right angles, to the given right circle: or quartering the primitive circle (by chapter 1. section 2. problem 8. of Practical Geometry, in page 15) with two diameters.

Example. Plate 3. fig. 7.

BCDE the primitive } circle, { and A its Center } given
BAD is a right } circle, { ———————— } given

To draw a right circle perpendicular to the right circle BAD is required?

Draw CAE perpendicular to BAD, or from the chords lay 90d. on the primitive circle from B, or from D to C and E; and through A and C, or A and E, draw a diameter and it's done.

Prob. 5. Case 3. *To draw an oblique circle perpendicular to a given right circle.*

The Rule. 1. Find the poles of the given right circle, by prob. 1. Case 2. of the Spheric Geometry, in page 103.

2. Draw a circle through those two poles, and it's done.

Example.

Example. Plate 3. fig. 7.

BCDE the primitive circle }
A the center thereof — — } given :
BAD is a right circle — }

To draw an oblique circle perpendicular to the right circle BAD is required.

1. Take the chord of 90d. and lay it from B, or D both ways to C and E, which are the two poles of the right circle BAD.

2. With any distance, and one foot on C and E, draw arches to cut each other in X, the center of the oblique circle CGF, required to be drawn.

Note, If AG be known, or limited to a certain distance, then its done by drawing a circle through the three puncts C, G, and E.

Or 2. If AG be any known quantity of degrees, then take the secant of its complement, and setting one foot on C, or E, the other will cross the given right circle, in the center of the oblique circle required to be drawn.

Prob. 5. Case 4. *To draw an oblique circle perpendicular to a given oblique circle.*

The Rule: 1. Find the poles of the given oblique circle, by prob. I. case 3. of Spheric Geometry, in pages 103, and 104.

2. Thro' their poles draw a great circle, which will cut the primitive circle diametrically opposite, and it's done.

Example. Plate 3. fig. 10.

BCDE the primitive } circle and { A } its center given
BFD an oblique } { Y }

To draw an other oblique circle, perpendicular to the oblique circle, BFD, is required.

1. Find G, the pole of the given oblique circle BFD, by prob. 1. case 3. of Spheric Geometry, in pages 103 and 104.

2. Through G. draw the circle HIGK, to cut the primitive in H and K, and the oblique circle BED in I (so that HAK is in a diameter) and it's done; for then BIH is a right angle, and the circles BIFD, and HIGK, are perpendicular to each other.

Note, 1. If the punct I (in the given oblique circle) is given, then draw a circle through I, and the pole G, by prob. 4. of Spheric Geometry, in page 105, and it's done.

Or, 2. If it be required that the said oblique circle shall make a certain angle at the primitive circle, then draw a circle thro' G, by prob. 3. of Spheric Geometry, in page 104.

Prob.

Prob. 6. *To lay any quantity of degrees on any great circle.*

In this problem are three cases.

Prob. 1. Case 1. *To lay any quantity of degrees on the primitive circle.*

The Rule. This is done by, or from the scale of chords.

Example. Plate 3. fig. 8.

BCDE the primitive circle, and A its center given.

To lay 40d. 30m. *on the primitive circle from* B *is required.*

From the scale of chords, take 40d. 30m. and lay it on the primitive circle from B to C, and it's done.

Prob. 6. Case 2. *To lay any quantity of degrees on a right circle.*

The Rule. This is done from the scale of half tangents, counting the beginning thereof to be the center of the primitive circle.

Example. Plate 3. Fig. 11.

BCDE the primitive circle, and A its center } given;
BAD is a right circle — — — }

On the right circle BAD, and from A, to lay 40d. 30m. or from B to lay 49d. 30m. is required.

From the half tangents, take 40d. 30m. and lay it on BAD from A to *l*; or 49d. 30m. the contrary way of the half tangents, laid from B to *l*, and it's done. For A *l* and *l* B together is equal to 90 degrees.

Prob. 6. Case 3. *To lay any quantity of degrees on an oblique circle.*

The Rule. 1. Find the poles of the given oblique circle, by prob. 1. case 3. of Spheric Geometry, in pages 103 and 104.

2. Lay the giving quantity of degrees on the primitive circle, by case 1. of this problem.

3. Reduce it from the primitive circle to the given oblique circle by the help of this pole, and it's done.

Example. Plate 3. fig. 11.

BCDE the primitive } circle, and { A } its center given;
BFD an oblique — } { Y }

On the oblique circle BFD (from B) to lay 51d. 30m. is required?

1. By Y and A, draw the diameter CAE, and find G the pole of the oblique circle, by prob. 1. case 3. in page 103.

2. From the scale of chords, take 51d. 30m. and lay it on the primitive circle, from B to H

3. Lay

3. Lay a scale on G and H, to cut the oblique circle BFD in L, then is BI on the oblique circle equal to 51d. 30m. as required.

Prob. 7. *To measure any part of a great circle.*

In this problem are three Cases, which are but the converse of in the last problem.

Problem 7. Case 1. *To measure any part of the primitive circle.*

The Rule. Take the part required to be measured, and lay it on the Scale of Chords, and it sheweth how much it is.

Example. Plate 4. fig. 8.

BCDE the primitive circle) and A its center given;
To measure BC, *a part of the primitive circle, is required,*
Take the extent BC in the compasses, and lay it on the Chords, which will shew how many degrees BC doth measure.

Prob. 7 Case 2. *To measure any part of a right circle.*

The Rule. 1. If the part to be measured lieth next the center of the primitive circle, then it's measured on the Scale of Half Tangents, from the Brass center-pin at the beginning thereof.

2. When the part to be measured lieth next the primitive circle, then it's measured on the Scale of Half Tangents, from 90 deg. counting 80d. to be 10d. 70 to be 20, 60 to be 30, &c.

Example. Plate 3. fig. 7.

BCDE the primitive circle, and A its center } given;
BAD a right circle — — — — — }
To measure A l, or B l, on the right circle BAD, is required?
1. Take A l, and lay it on the scale of Half Tangents from the brass center-pin (at the beginning of it) which will shew how many degrees it is. Or,
2. Take B l, and lay it on the scale of Half Tangents from 90d. backward, counting 80d. to be 10, and 70 to be 20, &c. so will it shew how many degrees B l is. And,
Note, That A l, and B l, will make together just 90d. they being complements to each other.

Prob. 7. Case 3. *To measure any part of an oblique circle.*

The Rule. 1. Find the poles of the given oblique circle, by prob. 1. case 3. of Spheric Geometry, in pages 103 and 104.
2. Lay a scale on either of the said poles and the part desired to be measured, and reduce it to the primitive circle.

3. It

3. It being reduced to the primitive circle, it's measured on the Scale of Chords, as before in case 1. of this problem.

Example. Plate 3. fig. 11.

BCDE the Primitive } Circle and { A } its Center given ;
BIFD an Oblique— } Circle and { Y } its Center given ;

To measure B I, and F I, on the oblique circle BIFD, is required.

1. Find G the poles of the oblique circle BIFD, by prob. 1. case 3. of Spheric Geometry, in pages 103 and 104.

2. Lay a scale on G and I, to cut the primitive circle in H.

3. Then EH measured on the scale of Chords, is the measure, of BI; and EH on the same scale of Chords is the measure of FI.

Prob. 8. *To measure any spheric angle.*

In this problem are four cases, and this is,

A general rule. A spheric angle is measured by the arch of a great circle, intercepted between the two containing sides, the angular punct being the pole of that circle. Or the distance of the poles of the containing sides, is equal to the measure of the containing angle.

Prob. 8. case 1. *To measure an angle, when its angular punct is the center of the primitive circle.*

The Rule. Such an angle is measured (like a plain angle) on the primitive circle, by a Scale of Chords.

Example. Plate 3. fig. 8.

BCDE the primitive circle, A its center, and the angular punct given : to measure the angle BAC is required.

Take BC, and measure it on the Scale of Chords, shews the angle how much it is.

Prob. 8. case 2. *To measure an angle, when its angular punct is at the primitive circle.*

The Rule. 1. Find the poles of the two containing sides by prob. 1. of Spheric Geometry, in pages 104 and 105.

2. The distance of those two poles, is the measure of the required angle.

Note 1. When the two poles are in one diameter or right circle, it's measured on the scale of half tangents.

2. When

2. When they are not in one diameter, then reduce them to the primitive circle, by laying a scale on the angular punct, and the said two poles, which distance being measured, on the scale of Chords, is the measure of the required angle:

Example. Plate 3. fig. 8.

BCDE the primitive BGFD an oblique	Circle, and	A Y	its Center given.

To measure the angle EDF *equal to the angle* EBF *is required.*

1. Through A and Y, draw a diameter to cut the primitive circle in H and I, and the oblique circle is G.

2. In the diameter IAH, find K, the pole of the oblique circle BGFD.

3. The distance AK, or GI, measured on the scale of half tangents (the latter the contrary way on that scale from 90d.) sheweth how much the angle EDF or EBF is.

Prob. 8. case 3. *To measure an angle when its angular punct is not in the center of, nor at the primitive circle.*

The rule is this. Find the two poles of the two containing sides, by problem 1. in pages 104 and 105.

2. Reduce these two poles to the primitive circles, then measure the distance of them on a Scale of Chords and it's done.

- *Note,* Reduce, is to lay a scale on the angular punct (required to be measured) and the said two poles to cut the primitive circle.

Example. Plate 3. fig. 8.

BCDE the Primitive BGFD an Oblique— CAFE a Right ——	Circle, and	A } its Center Y cuts the Oblique in F.	given

To measure the angle DFEBFE *is required.*

1. Through A and Y draw the diameter IAH, and in it find K the pole of the oblique circle BGFD ; as before in the last case.

2. Find L the pole of the right circle CAFE, by prob. 1. case 2. of Spheric Geometry, in page 104.

3. Reduce K to the primitive circle by laying a scale on F, and K to cut the primitive Circle) and its M : then LM measured on the Chords, sheweth how much the angle DFE, or BFE is ; one acute and the other obtuse.

Prob. 8. case 4. *To measure an angle when the containing sides are both oblique circles.*

Example. Plate 3. fig. 12.

BCDE the Primitive CHFE an Oblique BGFD an Oblique	circular and	A. Y X	its Center given ;

To measure the angle DFE, *or* BFE is required? 1. By

1. By A and Y, and A and X, draw two diameters; in them find I and K, the two poles of the containing sides, by prob. 1. case 3. of Spheric Geometry, in pages 103 and 104.

2. Reduce those two poles I and K. (by laying a scale on the angular punct F, and them) to cut the primitive circle in L and M; which being measured on the Chords sheweth how much the angle DFE, or BFE is; one acute, the other obtuse.

Prob. 9. *To draw a parallel circle.*

Definition. A parallel circle, or lesser circle, cutteth the sphere into two equal parts, and lieth parallel to a great circle: in this problem are three Cases.

Prob. 9. case 1. *To draw the parallel circle, parallel to the primitive circle, at any given distance from it, or from its pole.*

The Rule. With the half tangent of its distance from the pole, and one foot on the center of the primitive circle, draw a circle, and it's done.

Example. Plate 3. fig. 7.

BCDE the primitive circle, A its center given; to draw a circle parallel to BCDE, and 30d. distance from it is required?

With the half tangent of 60d. (the complement of 30d. and) its distance from the pole of the primitive circle, set one foot in A (the center and pole of the primitive) and describe the circle l m n o, which is parallel, as required.

Prob. 10. case 2. *To draw a parallel to a right circle.*

The Rule. 1. From the chords lay the parallel's distance from the right circle; or the complement thereof, from the pole of the right circle both ways, and note those two marks, on the primitive circle.

2. With the tangent of the parallel's distance from the pole of the right circle, and one foot on each of those two marks, describe arches, to cut each other in the center of the parallel circle required to be drawn.

Example. Plate 3. fig. 7.

BCDE the primitive circle, and A its center }
BAD as a right circle — — — — } given

To draw a circle parallel to BAD *at* 40d. *distance from it, or* 50d. *distance from* C, *its pole is required?*

1. Lay 40d. from B to p. and from D to q or lay its complement 50d. from C both ways to the said p and q.

With the tangent of 50d, and one foot on { p q } make the arch y; which crossing at y is the center of the parallel circle prq required to be drawn. Prob.

Prob. 9. case 3. *To draw a circle parallel to an oblique circle.*

The Rule. 1. Find the pole of the given oblique circle by prob. 1. case 3. in pages 103 and 104. which reduce to the primitive circle, and therefrom lay the parallels distance from the pole both ways, which being reduced to the right circle, is the diameter of the parallel circle.

2. Find the middle of those two marks which is the center of the parallel passing through those marks, and it's done.

Example. Plate 3. fig. 11.

BCDE the primitive } circle and { A } its center given ;
BIFD an oblique } circle and { Y } its center given ;

To draw a circle parallel to BIFD, at 40d. distance from it, or 50d. distance from its pole is required.

1. Find G the pole of the given oblique circle BIFD, by prob. 1. case 3. of Spheric Geometry, in pages 103 and 104.

2. Measure AG on the half tangents, and suppose it to be 30d. then add 50 to it, and subtract it from 50; the sum 80d. lay from A to k; and the difference 20d. lay from A to l. Or thus, reduce G to the primitive circle, and from it lay 50d. both ways, which reduce to the right circle, gives the same points k and l.

3. Find m the middle between k and l, and on m as a center draw a circle to pass through k and l, which is the parallel circle required to be drawn.

Thus much for Problems necessary for the making and measuring spheric triangles; which I advise the learner to acquaint himself with, and then the following applications will be the better understood.

Section II. *The use of the nine preceding problems, in making any spheric triangle, and measuring its parts; or the doctrine of spheric triangles geometrical.*

Definition 1. A Sphere or globe, is a round body made by the moving a semicircle about its own diameter, till the motion end where it first began. The semicircle's diameter, is the axis, or diameter of the spheric; in the middle of which is a punct, called the center; from whence all right lines drawn to the surface, or outside of the sphere are equal.

2. A spheric triangle, is described on the surface of the sphere; whose sides are the arches of three great circles mutually intersecting each other; and is either quadrantal, rectangular, or obliquangular.

3.	A quadrantal	triangular hath	one side	90d.
	A rectangular		one angle	
	An obliquangular		no side a quadrant	

or 90d. nor any angle 90d.

Note, 1. In every spheric triangle, each side is less than 180 degrees.

2. The sum of any two sides is greater than the third side.

3. The three sides added together, their sum is less than 360 degrees.

4. The sum of the three angles, is ever more than 180d. but less than 540d.

Prob. 10. *The hypotenuse and one leg given; to make a rectangular spheric triangle.*

Note, To make a rectangle spheric triangle, two things besides the rectangle must be given.

Example. Plate 4. fig. 1.

The { hypotenuse A C 54d. 25m. / leg B C — — 23d. 30m. } given:

With them to make a rectangle's spheric triangle is required.

1. Draw the primitive circle with a chord of 60d. a sine of 90d. or with a half tangent of 90d. and quarter it, which must be done in every Problem.

Then consider whether one of the oblique angles shall be at the primitive circle, or at its center.

First, If at the center of the primitive circle, then,

1. Draw (by problem 9. case 1. of Spheric Geometry) a circle parallel to the primitive, at 54d. 25m. (the given hypotenuse) distance from its pole; that is, with the half tangent of 54d. 25m. and one foot on A (the center of the primitive circle) describe a circle.

2. Then (by the 2*d*. case of the aforesaid Problem) draw a circle parallel to a right circle at 23d. 30m. (the given leg) distance from it: these two parallel circles cut each other in C.

3. Through A and C, draw a great circle, which in this case, is a right circle; that is, a diameter: and from C, (by prob. 5. case 3. of Spheric Geometry in page 107) draw a great circle perpendicular, or at right-angles to AB; which in this case will be an oblique circle, and it's done. Or,

Secondly, To make the triangle, that one of its oblique angles may be at the primitive circle.

1. The circle being described, and quartered, as before directed. Then,

2. Draw (by prob. 9. of Spheric Geometry) a circle parallel to a right circle, at 54d. 25m. distance from A its pole.

3. And

3. And (by the aforesaid Problem) draw a circle, parallel to the primitive circle, at 23d. 30m. distance from it, to cut the former parallel circle in C.

4. Then through A and C draw a great circle, which in this case will be an oblique circle: and from C (by prob. 5. case 1. of Spheric Geometry, in page 106) draw a great circle perpendicular to AB; which in this case will be a right circle, and it's done.

To measure the things required

The { leg AB ——— angles BAC and ACB } is measured by prob. { 17, page 109, 110.

Prob. 11. *The hypotenuse and one angle given; to make a triangle.*

Example. Plate 4. fig. 2.

The { hypotenuse AC 54d. 25m. angle BAC 29d. 30m. — } given,

With them to make a rectangle spheric triangle, is required.

First, To make the triangle, that the given angle BAC may be at the primitive circle's center.

1. Having described the primitive circle, and quartered it, as before directed in prob. 10. make the angle BAC equal to 29d. 30m. (by prob. 2. case 1. in page 104 of Spheric Geometry;) that is, from the scale of chords, lay 29d. 30m. on the primitive circle, and therefrom draw a line thro' A the center of the primitive circle.

2. Make AC equal to 54d. 25m. (by prob. 6. case 2. in page 109. of Spheric Geometry;) that is, from the scale of half tangents, lay 54d. 25m. from A to C.

3. By prob. 5. case 3. in page 106, draw a circle from C perpendicular unto AB, to cut the right circle AB in B; which in this case is an oblique circle, and it's done.

Secondly, To make the triangle so, that the given angle may be at the primitive circle.

1. After the primitive circle is made, and quartered as before, let A be one of those marks or quarters: then by (prob. 2. case 2. in page 104.) make the angle at A equal to 29d. 30m. by drawing an oblique circle with the secant of the given angle, as is the oblique circle AC.

2. Then by prob. 6. case 3. in page 109, lay 54d. 25m. on the oblique circle from A to C. or draw (by prob. 9. case 2. page 110.) a circle parallel to a right circle at 54d. 25m. distance from A it's pole, to cut the oblique circle AC in C.

3 By prob. 5. case 1. in page 106, draw a circle from C, perpendicular to the primitive circle AB to cut AB in B; which in this case is a right circle, and it's done.

To measure the things required.

The $\left\{\begin{array}{l}\text{leg AB and BC}\\\text{angle ACB —}\end{array}\right\}$ is measured by prob. $\left\{\begin{array}{l}\text{7. page 109.}\\\text{8. page 110.}\end{array}\right.$

Prob. 12. *A leg and its adjacent angle given; to make a triangle.*

Example. Plate 4. fig. 3.

The $\left\{\begin{array}{l}\text{leg AB —50d. 30m.}\\\text{angle BAC 29d. 30m.}\end{array}\right\}$ given:

With them to make a rectangle spherical triangle is required.

First, To make the triangle, that the given angle BAC, may be at the primitive circle's center.

1. The primitive circle being described, and quartered as before, and A placed at it's center; then (by prob. 2. case 1. in page 104 of Spheric Geometry) make the angle BAC equal to 29d. 30m. by drawing the right circle AC.

2. By prob. 6. Case 2. in page 109 make AB equal to 50d. 30m. that is from the scale of half tangents, lay 50d. 30m. on the right circle from A to B.

3. By prob. 5. case 3. in page 110. draw from B an oblique circle BC, perpendicular to the right circle AB, to cut the right circle AC in C, and it's done. Or thus,

From the scale of secants, take 39d. 30m. the complement of AB 50d. 30m. setting one foot in B, the other foot marks out (on the right circle AB extended) the center of the oblique circle BC which concludes the triangle.

Secondly, To make the triangle so, that the given angle may be at the primitive circle.

1. A being on or at the primitive circle, then (by prob. 2. case 2. in page 104) make the angle BAC equal to 29d. 30m. by drawing the oblique circle AC, with the secant thereof.

2. By prob. 6. case. 1. in page 106, make AB (on the primitive circle) equal to 50d. 30m. by laying the chord of it, from A to B.

3. By prob. 5. case 1. in page 106, draw a great circle from B, perpendicular to AB, at the right circle BC, to cut the oblique circle AC in C, and it's done.

To measure the things required.

The $\left\{\begin{array}{l}\text{leg BC, and hypot. AC}\\\text{angle ACB———}\end{array}\right\}$ is measured by prob. $\left\{\begin{array}{c}7\\8\end{array}\right\}$ in pages 109, 110 and 111.

Prob. 13. *A leg and its opposite angle given; to make a triangle.*

Example. Plate 4. fig. 2.

The $\left\{\begin{array}{l}\text{leg BC——23d. 30m.}\\\text{angle BAC 29d. 30m.}\end{array}\right\}$ given:

With them to make a rectangle spheric triangle, is required.

First

First, To make the triangle, with the given angle at the primitive circle's center.

1. The primitive circle drawn, &c. as before, and A at its center, then (by prob. 2. case 1. in page 104) make the angle BAC equal to 29d. 30m. by drawing two right circles AB and AC.

2. Draw (by prob. 5. case 2. in page 115) a parallel circle, parallel to the right circle AB, at 23d. 30m. distance from it, to cut the circle AC, in C.

3. From C, (by prob. 5. case 3. in page 106) draw an oblique circle BC, perpendicular to the right circle AB, to cut AB in B; and it's done.

Secondly, To make the triangle, that the given angle may be at the primitive circle,

1. A being at the primitive circle, then (by prob. 2. case 2. in page 104) make the angle BAC equal to 29d. 30m.) by drawing the oblique circle AC, with the secant thereof.

2. By prob. 9. case 1. in page 111, draw a parallel circle, parallel to the primitive circle AB, at 23d. 30m. distance from it, to cut the oblique circle AC in C. Or thus, with the half tangent 66d. 30m. (the complement of 23d. 30m.) and one foot in the center of the primitive circle, with the other cut the oblique circle in C.

3. From C (by prob. 5. case 1. in page 106) draw a right circle BC, perpendicular to the primitive circle AB to cut AB, in B, and it's done.

To measure the thing required.

The { hypot. AC and leg AB / angle ACB——— } is measured by prob. { 7. / 8. } in pages 109, 110, 111.

Prob. 14. *Both legs given to make a triangle.*

Example. Plate 4. fig. 5.

The leg { AB 50d. 30m. / BC 23d. 30m. } given:

With them to make a rectangle spheric triangle; is required.

First, To make the triangle, that one of the oblique angles may be at the primitive circle's center.

1. A being at the center of the primitive circle, draw the right circle AB, and thereon (by prob. 6. case 2. in page 106) make AB equal to 50d. 30m. by laying the half tangent thereof, from A to B.

2. From B (by prob. 5. case 3. in page 105) draw an oblique circle BC perpendicular to AB. Or thus,

With the secant of 39d. 30m. (the complement of 50d. 30m.) and one foot on B, the other foot marks out (in the right

right circle AB extended) the center of the oblique circle BC.

3. Draw (by prob. 9. case 2. in page 111) a parallel circle parallel to the right circle AB, at 23d. 30m. distance from it, to cut the oblique circle BC in C. Or thus,

By prob. 6, case 3. in page 109. lay 23d. 30m. on the oblique circle from B to C.

4. Through A and C draw a great circle; which in this case is a right circle, and it's done.

Secondly, to make the triangle, that one of the oblique angles may be at the primitive circle.

1. By prob. 6. case 1. in page 109. make AB equal to 50d. 30m. by laying the Chords thereof on the primitive circle from A to B.

2. From B (by prob. 5. case 1. in page 106) draw a great circle perpendicular to the primitive circle (which in this case is a right circle) as BC.

3. Draw (by prob. 9. case 1. in page 111) a parallel circle, parallel to the primitive circle AB, at 23d. 30m. distance from it, to cut the right circle BC in C. Or thus,

From the scale of half tangents, lay 66d. 30m. (the Complement of 23d. 30m.) from the center of the primitive Circle, on the right Circle to C.

4. Through A and C, draw a great circle; which in this case is an oblique circle, and it's done.

To measure the things required.

The $\left\{\begin{array}{l}\text{hypotenuse AC}\text{———}\\ \text{angles BAC, and ACB}\end{array}\right\}$ is measured by prob. $\left\{\begin{array}{l}7.\\ 8.\end{array}\right\}$ in pages 110, 111.

Prob. 15. *Both the angles given; to make a triangle.*

Example, Plate 4. fig. 6.

The angle $\left\{\begin{array}{l}\text{BAC 29d. 30m.}\\ \text{ACB 71d. 56m.}\end{array}\right\}$ given

With them to make a rectangle spheric triangle, is required.

1. By prob. 2. case 2. in page 104, make the angle BAC equal to 29d. 30m. by drawing the oblique circle AB, with the secant thereof.

2. Find I, the pole of the oblique circle AB, by prob. 1. case 3. in pages 103 and 104.

3. Through I (by prob. 3. in page 104) draw an oblique circle IBC, that the angle ABC may be 71d. 56m. which will cut the oblique circle AB, in B the rectangle, and the primitive circle in C, and so conclude the rectangle triangle ABC required to be made.

To measure the things required.

The hypotenuse AC and legs AB and BC, are measured by prob. 7. of Spheric Geometry, in pages 109 and 110.

Thus

Thus all the cases of rectangle spheric triangles may be described, and resolved by the last six problems. In like manner the cases of oblique triangles may be geometrically solved by the six following.

Prob. 16. *Two sides and an angle opposite given; to make an oblique spheric triangle.*

Note, To make an oblique spheric triangle, three things must be given.

Note also, The angle opposite to the other given side ought to be foreknown, whether acute or obtuse: otherwise two several triangles may be made from the given things.

Example. Plate 4. fig. 7.

The { side — AC 34d. 07m. / side — AD 65d. 20m. / angle ADC 27d. 33m. } given;

With them to make a triangle (so that the angle ACD may be obtuse) is required.

1. On the primitive circle make AD (the given side joining to the given angle) equal to 65d. 20m. by prob. 6. case 1. of Spheric Geometry.

2. By prob. 2. case 2. make the angle ADC equal to 27d. 33m. by drawing the oblique circle DC, with the secant thereof.

3. Draw (by prob. 9. case 2.) a parallel circle at 34d. 07m. distance from A, to cut the oblique circle DC, in C.

4. Through A and C draw a great circle, and it's done.

To measure the things required.

The { Angles CAD, and ACD / Side— CD } is measured by prob. { 7 / 8 }

Prob. 17. *Two angles and one side opposite given; to make an oblique spheric triangle.*

Example. Plate 4. fig. 8.

The { angle CAD 30d. 48m. / angle ADC 27d. 30m. / side — CD 38d. 28m. } given;

With them to make a triangle (so that the side AC may be less than 90d.) is required.

1. By prob. 2. case 2. make the angle ADC equal to 27d. 30m. (always the angle joining to the given side) by drawing the oblique circle DC with the secant of it.

2. Draw (by prob. 9. case 2.) a parallel circle at 38d. 28m. distance from D, to cut the oblique circle DC in C.

 3. Then

3. Then through C (by prob. 3.) draw a great circle to make an angle at the primitive circle, that may be equal to 30d. 48m. as is the oblique circle CA, and it's done.

To meaſure the things required.

The { ſides AC and AD / angle ACD—— } is meaſured by prob. { 7 / 8 }

Note, In theſe two laſt problems, the three given things without the quality of a fourth are not ſufficient to make a triangle: and the quality of the fourth is not always diſcoverable by the given things; therefore they are called Doubtful Caſes.

Prob. 18. *Two ſides and one angle between them given; to make an oblique ſpheric triangle.*

Example. Plate 4. fig. 9.

The { ſide——AC 34d. 06m. / ſide——AD 65d. 20m. / angle CAD 30d. 46m. } given.

With them to make a triangle is required?

1. By prob. 2. caſe 2. make the angle CAD equal to 30d 46m. by drawing the oblique circle AD with the ſecant thereof.

2. Make AC on the primitive circle equal to 34d. 06m. and AD on the oblique circle equal to 65d. 20m. by prob. 6. caſe 1. and 3.

3. Through C and D draw a great circle, and it's done.

To meaſure the things required.

The { ſide———CD——— / angles ACD and ADC } is meaſured by prob. { 7 / 8 }

Prob. 19. *Two angles and one ſide between them given; to make an oblique triangle.*

Example. Plate 4. fig. 10.

The { angle ACD 131d. 34m. / angle ADC 27d. 30m. / ſide — CD 38d. 28m. } given:

With them to make a triangle is required?

1. On the primitive circle make CD equal to 38d. 28m. the given ſide, by prob. 6. caſe 1.

2. At C (by prob. 2. caſe 2.) make the angle ACD equal to 131d. 34m. by drawing the oblique circle AC; and at D make the angle ADC equal to 27d. 30m. by drawing the oblique circle DA and it's done.

To meaſure the things required.

The { ſides AC, and AD / angle CAD —— } is meaſured by prob. { 7 / 8 }

Prob.

Prob. 20. *Three sides given; to make a triangle.*

Example. Plate 4. fig. 11.

The side $\left\{\begin{array}{l}\text{AD } 65\text{d. } 20\text{m.}\\ \text{CD } 38\text{d. } 26\text{m.}\\ \text{AC } 34\text{d. } 08\text{m.}\end{array}\right\}$ given:

With them to make an oblique triangle is required.

1. On the primitive circle make AD equal to 65d. 20m. (the greater given side) by prob. 6. case 1.

2. Draw (by prob. 9. case 2.) a parallel circle at 34d. 20m. distance from A, and likewise another at 38d. 26m. distance from D, to cut each other in C.

3. Through A and C, and also D and C, draw great circles, and it's done.

To measure the things required,

1. Find (by prob. 1.) the poles of the three sides of the triangle ACD; that is, E the pole of AD, F the pole of AC, and G the pole of CD.

2. Through F and G (by prob. 4.) draw a great circle which will form a triangle EFG.

3. The sides of the triangle EFG are equal to the angles of the triangle ACD; and the angles of the first are equal to the sides of the latter, only the greater angle in the one, is equal to the supplement (of the greater side in the other) to 180d.

That is, the side EF is equal to the angle CAD, the side EG is equal to the angle ADC, and the side FG is equal to the supplement to 180d. of the angle ACD.

4. The side EF, EG, are measured by prob. 7.

Prob. 21. *Three angles given; to make a triangle.*

Example. Plate 4. fig. 12.

The angle $\left\{\begin{array}{l}\text{CAD } 131\text{d. } 34\text{m.}\\ \text{ACD } 30\text{d. } 47\text{m.}\\ \text{ADC } 27\text{d. } 30\text{m.}\end{array}\right\}$ given;

With them to make an oblique triangle, is required;

1. Suppose a triangle EFG, whose sides are equal to the angles of the triangle ADC; that is, the side EF equal to 48d. 26m. the supplement to 180d. of the angle CAD equal to 131d. 34m. and the side EG equal to the angle ACD 30d. 47m. and the side FG equal to the angle ADC 27d, 30m.

2. Then make the triangle EFG of the sides EF; EG and FG; as before in the last problem.

3. Find (by prob. 1.) the poles of the three sides of the triangle EFG; that is, A the pole of EF, C the pole of EG, and D the pole of FG.

4. Through

4. Through C and D (by prob. 3.) draw a great circle, which will form the triangle ACD required to be made.

To measure the things required.

The sides AC, AD, and CD, are measured by prob. 7.

Thus much I thought necessary as preparative to spheric trigonometry by calculation; that the learner might know how to make and measure a spheric triangle, or any of its parts; a thing not taught by many, nor well understood by more, who pretend to be teachers.

Sect. III. *Of the affections or natural properties of Spheric Triangles.*

These Affections are carefully to be minded, in order to the understanding what may be, and what may not be given, or required in the spheric triangle; and having already given you the several definitions of a sphere, and the circles of it, with the kinds of triangles, which I shall not here repeat. I pass on to the Affections of Spheric Triangles, as follows,

1. Every side of a spheric triangle is an arch of a great circle, and less than a semi-circle.

2. Every great circle devides the sphere or globe, into two equal parts or hemispheres.

3. Any two great circles cutting each other; the angles, which are opposite and contrary, are equal.

4. The sum of any two sides (of a triangle) is greater than the third side.

The sum of the three $\left\{\begin{array}{l}\text{sides}\\ \text{angles}\end{array}\right\}$ is less than $\left\{\begin{array}{l}\text{360d.}\\ \text{540d.}\end{array}\right.$ but more than 180d.

6. Any two sides added together, their sum is less than the difference between the third side and 180d. But

Any two angles added together, their sum is more than the difference between the third angle and 180d.

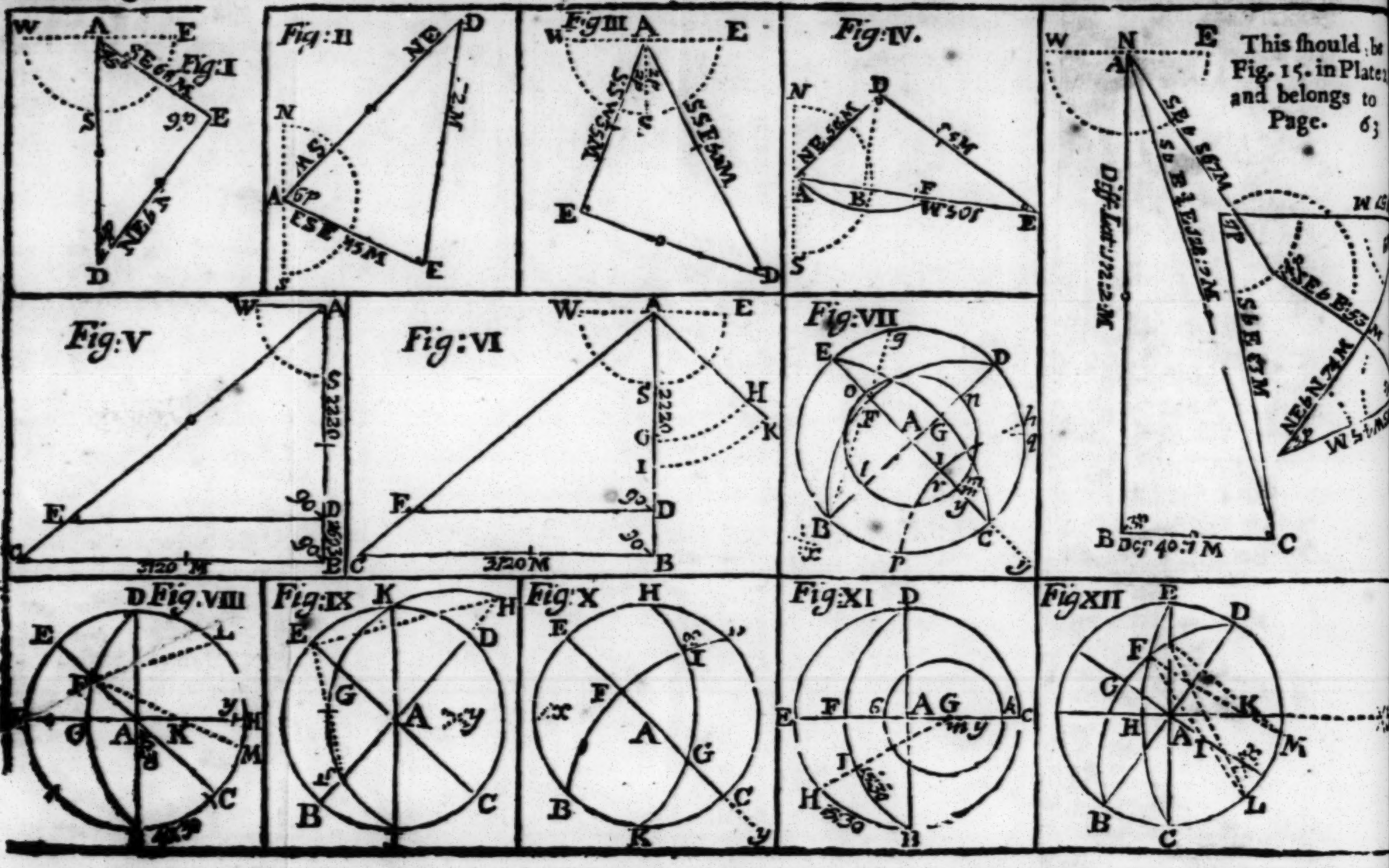
7. In the rectangular triangle, the legs and their opposite angles are of the same affection; that is, if a leg be more or less than a quadrant, its opposite angle is likewise more or less than a right angle.

8. In a rectangular triangle, if one leg be a quadrant, the hypotenuse shall be a quadrant; but if both legs be of the same affection, the hypotenuse is less than a quadrant; if of different it's more, and the contrary; that is, if each of the legs be less or more than 90d. the hypotenuse is less than 90d. but if one leg be more than 90d. and the other less, the hypotenuse is more than 90d.

9. If the hypotenuse be $\left\{\begin{array}{l}\text{less}\\ \text{more}\end{array}\right\}$ than 90d. one leg, and its

opposite

Plate 3. Place this next after Page



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opposite angle will be $\left\{\begin{array}{l}\text{less than 90d. the other may, or not}\\ \text{more than 90d.}\end{array}\right.$

10. If both angles at the hypotenuse are acute or obtuse, the hypotenuse is less than a quadrant, but if one be acute, and the other obtuse, the hypotenuse is more than a quadrant.

11. In every triangle, greatest sides are opposite to greatest angles, and equal sides to equal angles.

12. In every Oblique Triangle two $\left\{\begin{array}{c}\text{Acute}\\ \text{Obtuse}\end{array}\right\}$ Angles being equal their opposite sides are equal, each $\left\{\begin{array}{c}\text{less}\\ \text{more}\end{array}\right\}$ than a quadrant

13. If two $\left\{\begin{array}{c}\text{acute}\\ \text{obtuse}\end{array}\right\}$ Angles are unequal, the side opposite to the $\left\{\begin{array}{c}\text{lesser}\\ \text{greater}\end{array}\right\}$ angle, shall be $\left\{\begin{array}{c}\text{less}\\ \text{more}\end{array}\right\}$ than a quadrant

14. If all the angles are acute, each side is less than a quadrant.

These things being premised, their solution followeth; and first of Rectangular, in which are 16 cases; and then Oblique-angular, in which are 12 cases.

Sect. IV. *The solution of the 16 cases of Rectangular Spheric Triangles, by the lord* Napier's *catholic proposition.*

IN a rectangular triangle, there are (besides the right-angle) 1. five things, which the lord Napier calleth the five circular parts of a spheric triangle, amongst which, the right angle being not reckoned, the two legs are supposed to join together.

2. Any one of these five circular parts, may, by supposition, be made a middle part, and then the two circular parts which are next to that middle part, are the extreams conjunct. And the other (two circular parts) remote from that (assumed middle part) are the extreams disjunct.

3. In every case, two of the aforesaid five circular parts, is (always) give to find a third; these three things (two given, and one required) of them, one is middle part, and the other two are extreams, either conjunct or disjunct.

The parts of a rectangular triangle being thus distinguished, observe the universal proposition following, invented by the aforesaid lord, the inventor of Logarithms.

The catholic proposition.

The sine of a middle part and radius, are reciprocally proportional with the tangents of the extreams conjunct; and with the sine complement of the extreams disjunct. That is,

1. *For extreams conjunct, thus*;

As radius, is to the tangent of one extream; so is the tangent of the other, to the sine of the middle part. And,

2. For

2. *For extreams disjunct, thus.*

As radius, is to the sine complement of one extream; so is the sine complement of the other, to the sine of the middle part. Therefore,

Note; When the middle part is to be found, the radius is the 1st term in the proportion, as above; but if either of the extreams be required, the other extream must be the first term, That is,

3. *For extreams conjunct, thus*,

As the tangent of the given extream, is to radius; so is the sine of the middle part, to the tangent of the required extream. And,

4. *For extreams disjunct thus*;

As the sine complement of the given extream, is to radius; so is the sine of the middle part, to the sine complement of the required extream. But,

Note 1. That if the middle part, or either of the extreams conjunct be the hypotenuse, or either of the oblique angles; instead of sine and of tangent, you must use the sine complement, and tangent complement.

A TABLE of all the varieties of extreams conjunct and disjunct.

Number	Middle part	Ext. conjunct	Ext. disjunct.
1	Sine AB	Tang. BC Tan. c. BAC	Sine ACB Sine AC
2	Sine c. BAC	Tan. c. AC Tan. AB	Sine c. BC Sine ACB
3	Sine c. AC	Tan. c. ACB Tan. c. BAC	Sine BC Sine AB
4	Sine c. ACB	Tan. c. C Tan. BC	Sine BAC Sine c. AB
5	Sine c. BC	Tan. AB Tan c. ACB	Sine BAC Sine AC

2. If either of the extreams disjunct be the hypotenuse, or either of the oblique angles, instead of sine complement you must use the sine.

And for the easier understanding these directions, observe the table foregoing; wherein are placed the five circular parts of a triangle, under their respective titles, whether they be taken for the middle part, or for extreams, either conjunct or disjunct: and unto those parts are perfixed, sine, sine-complement; tangent and tangent complement, as they ought to be, and are used in the case following.

Prob,

Prob. 1. case 1, 2, and 3. *The hypotenuse, and one leg given*;

$$\text{To find}\left\{\begin{array}{c}1\\2\\3\end{array}\right\}\text{The}\left\{\begin{array}{l}\text{angle adjacent}\\\text{angle opposite}\\\text{other leg.}\end{array}\right\}\text{to the given leg ?}$$

Example. Plate 4. fig. 1.

In the triangle ABC, right angled at B; there is given

$$\text{The}\left\{\begin{array}{l}\text{hypot. AC 54d. 25m.}\\\text{leg BC 23d. 30m.}\end{array}\right\}\begin{array}{l}\text{ACB, BAC}\\\text{and AB——}\end{array}\Big\}\text{required.}$$

This triangle is made by prob. 10. of Spheric Trigonometry Geometrical.

1. For the contained angle ACB or angle adjacent to the given leg, the proportion is.

As radius is to the tangent of the given leg; so is the tangent complement of the hypotenuse, to the sine complement of the contained angle required. Or thus,

Radius ·· T. leg BC :: T. c. hypot. AC ·· S. c. angle ACB

T. 45d. ·· T. 23d. 30m. :: T. 35d. 35m. ·· S. 18d. 16m.

Which subtract from 90d. rest 71d. 54m. for the angle ACB required.

Therefore the extent (on the Gunter's Scale) from tangent of 45d. to tangent of 23d. 30m. reacheth from tangent 35d. 35m. to the tangent 17d. 15m. against which on the line of sines, is 18d. 16m. the 4th term in the proportion above.

$$\textit{Note},\text{ the Hyp. and given leg. }\left\{\begin{array}{c}\text{each}\\\text{one}\end{array}\right\}\text{ more}\left\{\begin{array}{c}\text{or———}\\\text{the other}\end{array}\right\}\text{ less}$$

$$\text{than a quadrant, or 90d. the required angle is}\left\{\begin{array}{l}\text{acute}\\\text{obtuse}\end{array}\right.$$

2. For the angle BAC opposite to the given leg, the proportion is thus;

As the sine of the hypotenuse, is to radius; so is the sine of the given leg, to the sine of its opposite angle. Or thus;

S. hypot. AC ·· radius :: S. leg. BC .. S. Angle BAC.

S. 54d. 25m. ·· S. 90d. :: S. 23d. 30m... sine 29d. 30m.

Therefore the extent (on the Gunter) from sine 54d. 25m. to sine of 90d. reacheth from sine of 23d. 30m, to sine of 29d. 30m. the fourth term in the proportion aforesaid.

$$\textit{Note},\text{ the given leg }\left\{\begin{array}{c}\text{less}\\\text{more}\end{array}\right\}\text{ than a quadrant, the required angle is}\left\{\begin{array}{l}\text{acute}\\\text{obtuse}\end{array}\right.$$

3. For the other leg AB, the proportion is thus;

As the Sine-Complement of the given leg, is to radius; so is the Sine-complement of the hypotenuse, to the Sine-Complement of the required leg; or thus;

S. c.

S. c. leg BC ·· Radius :: S. c. hip. AC.. S. c. leg AB required.
S. 66d. 30m. ·· S. 90d. :: S. 35d. 35m. .. S. 39d. 35m. which subtract from 90. resteth 50d. 25m. for the leg AB required.

Therefore the extent (on the Gunter's Scale) from Sine of 66d. 30m. to Sine of 90d. will reach from Sine of 35d. 35m. to Sine of 39d. 35m. the fourth term in the proportion aforesaid.

Note; The hypotenuse and given leg of {one / different} kind the required leg is {less / more} than a quadrant.

Prob. 2. case 4, 5, *and* 6.

The hypotenuse, and one leg given,

To find {1 leg opposite / 2 leg adjacent} to the given angle? {3 other angle}

Example. Plate 4. fig. 2.

In the triangle ABG right-angled at B; there is given {hipt. AC 54d. 25m. / angle BAC 29d. 30m.} {leg BC and AB, and / angle ACB required};

This triangle is made by prob. 11. of Spheric Trigonometry Geometrical.

1. For the leg BC opposite to the given angle, the proportion is thus;

As radius is to the Sine of the hypotenuse, so is the Sine of the given angle, to the Sine of its opposite leg required. Or thus;

Radius .. S. hipot. AC :: S. angle BAC.. S. leg. BC.
S. 90d. .. S. 54d. 25m. :: S. 29d. 30m. ·· S. 33d. 32m.

Note, The given angle {acute / obtuse} the leg found {less / more} than a quadrant

2. For the leg AB, adjacent to the given angle, the proportion is this;

As the Tangent Complement of the hypotenuse, is to radius; so is the Sine Complement of the given angle, to the tangent of its adjacent leg required. Or,

As radius, is to the sine complement of the given angle; so is the tangent of the hypotenuse, to the tangent of the leg required; that is,

Radius ·· S. c. BAC :: T. hipot. AC .. T. leg AB required.
S. 90d. ·· S. 60d. 30m. :: T. 55d. 25m. .. T. 50d. 30m.

Note; When each given thing is less, or more than 90d. the required leg is less than a quadrant, but if one is less, and the other more, the required leg is more than a quadrant.

3. For

3. For the other angle ACB, the proportion is this;

As the Tangent Complement of the given angle is to radius; so is the Sine Complement of the hypotenuse; to the Tangent Complement of the other angle required. Or thus;

As radius, is to the Sine Complement of the hypotenuse; so is the tangent of the given angle, to the Tangent Complement of the angle required. That is;

Radius .. S. c. hipot. AC :: T. angle BAC .. T. c. angle ACB

S. 90d. .. S. 35d. 35m. :: T. 29d. 30m. .. T. 18d. 10m.

Which subtract from 90d. rests 71d. 50m. for the angle ACB.

Note; When each given thing is less, or more than 90d. the required angle is acute: but when one is more, and the other less, it's obtuse.

Prob. 3. case 7, 8, and 9. *A leg and its adjacent angle, given.*

To find { 1 leg, 2 the angle } opposite to the given { angle, leg. }
{ 3 hypotenuse }

Example. Plate 4. fig. 3.

In the triangle ABC, right angled at B, there is.

given { leg——AB 50d. 30m. / angle BAC 29d. 30m. } { leg AC, angle ACB, and hypot. AC required. }

This triangle is made by prob. 12. of Spheric Trigonometry Geometrical.

1. For the leg BC opposite to the given angle, the proportion is;

As the tangent complement of the given angle is to radius; so is the sine of its adjacent leg, to the tangent of its opposite leg required. Or thus;

As radius, is to the sine of the given leg; so is the tangent of its adjacent angle to the tang. of its opposite leg. That is;

Radius .. S. leg. AB :: T. angle BAC .. T. leg BC req.

S. 90d. .. S. 50d. 30m. :: T. 29d. 30m. .. T. 23d. 35m.

Note, The given angle acute, the required leg is less than a quadrant, but when obtuse then more than a quadrant.

2. For the angle ACB, opposite to the given leg, the proportion is;

As radius, is to the sine complement of the given leg; so is the sine of its adjacent angle to the sine complement of its opposite angle required. That is,

Radius .. Sc. leg AB :: S. angle BAC .. Sc. angle ACB req.

S. 90d. .. S. 39d. 30m. :: S. 29d. 30m. .. S. 18d. 12m.

whose complement 71d. 48m. is the angle ACB.

Note; The given leg less or more than 90d. the angle required is acute, or obtuse accordingly.

2. For the hypotenuse the proportion is:

As

As the tangent of the given leg, is to radius, ſo is the ſine complement of its adjacent angle, to the tangent complement of the required hypotenuſe. Or thus;

As radius is to the ſine complement of the given angle; ſo is the tangent complement of its adjacent leg, to the tangent complement of the hypotenuſe. That is;

Radius ·· Sc. angle BAC :: Tc. leg. AB .. Tc. hypot. AC

S. 90d. ·· S. 60d. 30m. :: T. 39d. 30m. ·· T. 35d. 38m.

whoſe complement 54d. 22m. is the hypotenuſe AC.

Note; When each thing is leſs, or more than 90d. the hypotenuſe is leſs than a quadrant, but if one is leſs, and the other more, then the hypotenuſe is more than a quadrant.

Prob. 4. caſe 10, 11, and 12, *A leg and its oppoſite angle given*;

$$\text{To find}\left\{\begin{matrix}1\\2\\3\end{matrix}\right\}\text{the}\left\{\begin{matrix}\text{leg}\\\text{angle}\\\text{hypotenuſe.}\end{matrix}\right.\left.\begin{matrix}\\ \\ \end{matrix}\right\}\text{adjacent to the given}\left\{\begin{matrix}\text{angle;}\\\text{leg?}\end{matrix}\right.$$

Example, Plate 4. fig. 4.

In the triangle BAC, right-angle at B; there is

given { leg ——BC 23d. 30m. / angle BAC 29d. 30m. } leg AB, angle ACB, and hypotenuſe AC required.

This triangle is made by prob. 13. of Spheric Trigonometry Geometrical.

1. For the leg AB adjacent to the given angle, the proportion is this:

As radius is to the tangent of the given leg; ſo is the tangent complement of its oppoſite angle to the ſine of the other leg required. That is;

Radius T ·· leg BC :: Tc. angle BAC ·· S. leg AB required.

T. 45d. ·· T 23d. 30m. :: T. 60d. 30m. ·· 50d. 25m.

Note; If the unknown angle be acute or obtuſe, the required leg accordingly is leſs or more than a quadrant.

Or the hypotenuſe and given leg, each leſs or more than 90d. the required leg is leſs than a quadrant, but if one is more and the other leſs, its more than 90d.

2. For the angle ACB adjacent to the given leg, the proportion is this;

As the ſine complement of the given leg is to radius; ſo is the ſine complement of its oppoſite angle, to the ſine of its adjacent angle. That is,

Sc. leg BC ·· radius :: Sc. angle BAC ·· S. angle ACB

S. 66d. 30m. · S. 90d. :: S. 60d. 30m. ·· S. 71d. 48m.

Note, If the hypotenuſe and given angle be each leſs, or more than 90d. the angle required is acute; but when one is more and the other leſs, its obtuſe. Or,

Or, the leg adjacent to the given angle being less, or more than 90d. accordingly the angle required is acute or obtuse.

3. For the hypotenuse AC, the proportion is thus;

As the sine of the given angle, is to radius; so is the sine of its opposite leg, to the sine of the hypotenuse required. That is,

S. angle BAC ·· radius :: S. leg BC ·· S. hypoten. AC req.

S. 29d. 30m. ·· S. 90d. :: S. 23d. 30m. ·· S. 54d. 20m.

Note, If both legs, or both angles be of one kind, the hypotenuse is less than a quadrant, but if they be of different kinds, the hypotenuse is more than a quadrant.

Prob. 5. case 13, and 14. *Both legs given; to find 1. either of the angles? 2. The hypotenuse?*

Example. Plate 4. fig. 5.

In the triangle ABC, right angled at B; there is,

given deg. { AB 50d. 30m. } angle BAC, or ACB, and
{ BC 23d. 30m. } hypotenuse AC required.*

This triangle is made by prob. 14. of Spheric Trigonometry Geometrical.

1. For either of these angles, the proportion is;

As the tangent of one leg is to radius, so is the sine of the other leg to the tangent complement of the angle opposite to the first leg. Or thus,

As radius, is to the sine of one leg; so is the tangent complement of the other leg, to the tangent complement of the angle opposite to the last leg. That is,

Radius ·· S. leg AB :: T. c. leg BC ·· T. c. angle BAC,

S. 90d. ·· T. 50d. 30m. :: T. 66d. 30m. ·· T. 60d, 35m. whose complement is 29d. 25m. is the angle BAC, also it is,

Radius ·· S. leg BC :: T. c. leg AB :: T. c. angle ACB

S. 90d. ·· S. 23d. 30m. :: T. 39d. 30m. ·· T. 18d. 15m. whose complement 71d. 45m. is the angle ACB.

Note, If the leg opposite to the required angle be less than a quadrant, the angle sought is acute; but when greater, then it's obtuse.

2. For the hypotenuse, the proportion is thus;

As radius, is to the sine complement of one leg, so is the sine complement of the other leg, to the sine complement of the hypotenuse. That is,

Radius ·· S. c. leg. AB :: S. c. leg BC ·· S. c. hypotenuse AC.

S. 90d. ·· S. 39d. 30m. :: S. 66d. 30m. ·· S. 35d. 40m. whose complement 54d. 20m. is the hypotenuse AC.

Note, If both legs be of one kind, the hypotenuse is less than a quadrant, but when of different kinds (that is one leg more, the other less than a quadrant;) then the hypotenuse is more than a quadrant.

Prob. 6. case 15, and 16. *Both the oblique angles given, to find 1. either of the legs? 2. the hypotenuse?*

Example. Plate 4. fig. 6.

In the triangle ABC, right angled at B; there is given

Angle { BAC 29d. 30m. } leg AB or BC, and
{ ACB 71d. 56m. } hypotenuse AC required.

This triangle is made by prob. 15. of Spheric Trigonometry Geometrical.

1. For either of the legs, the proportion is thus;

As the sine of one angle is to radius; so is the sine complement of the other angle, to the sine complement of its opposite leg. That is,

S. angle BAC ·· radius :: S. c. angle ACB ·· Sc. leg AB.

S. 29d. 30m. ·· S. 90d. :: S. 18d. 04m. ·· 40d. 45m.

whose complement 49d. 15m. is the leg AB; also it is,

S. angle ACB ·· radius :: S. c. angle BAC ·· S. c. leg BC.

S. 71d. 56m. ·· S. 90d. :: S. 60d. 30m. ·· S. 66d. 30m.

whose complement 23d. 30m. is the leg BC.

Note, If the angle opposite to the required leg be acute, the leg sought is less than a quadrant; but if obtuse, then greater than a quadrant.

2. For the hypotenuse, the proportion is thus;

As radius, is to the tangent complement of one Angle; so is the tangent complement of the other Angle, to the sine complement of the hypotenuse. That is,

Radius ·· T. c. angle BAC :: T. c. angle ACB ·· Sc. hypot. AC.

T. 45d. ·· T. 60d. 30m. :: T. 18d. 04m. ·· S. 35d. 35m.

whose complement 54d. 25m. is the hypotenuse AC.

Note, The angles of one kind, the hypotenuse is less than a quadrant; but when of different kinds, it's more than a quadrant.

Sect. V. *Four axioms, by which the 12 cases of oblique angled spheric triangles are solved.*

Axiom 1. IN all spheric triangles, the sine of their sides are in direct proportion to the sines of their opposite angles. That is,

1. As the sine of a side, is to the sine of its opposite angle; so is the sine of another side, to the sine of its opposite angle.

2. As the sine of an angle, is to the sine of its opposite side; so is the sine of another angle, to the sine of its opposite side.

Axiom 2. *First*, As the sine of half the sum of the two sides (containing an angle) is to the sine of half their difference;

So is the tangent complement of half the contained angle, to the tangent of half the difference of the other two angles.

Again,

Again,

Secondly, As the sine complement of half the sum of two sides (containing an angle) is to the sine complement of half their difference;

So the tangent complement of half the contained angle, to the tangent of half the sum of the other two angles.

Axiom 3. *First*, As the sine of half the sum of two angles is to the sine of half their difference;

So is the tangent of half their interjacent side, to the tangent of half the difference of the other two sides. Again,

Secondly, As the sine complement of half the sum of two angles is to the sine complement of half their difference;

So is the tangent of half their interjacent side, to the tangent of half the sum of the other two sides.

Axiom 4. As the rectangle of the sines of the two containing sides, is to the square of radius;

So is the rectangle of the sines of half the sum of the three sides, and of the difference of the side opposite thereto, to the square of the sine complement of half the contained angle sought.

The explanation and use of these 4 Axioms, you will find in the solution of the following cases of Oblique Triangles.

Prob. 7. case 1, 2, and 3.

Two sides and an angle opposite given; to find

1. The angle opposite to the other side.
2. The angle contained between them.
3. The third side

} if the required opposite angle be foreknown to be acute or obtuse.

Example. Plate 4. fig. 7.

In the oblique triangle ACD *there is*

given	side AC	34d. 07m.	angle ACD being obtuse		req.
	side AD	65d. 20m.	angle CAD		
	angle ADC	27d. 30m.	side CD		

This triangle is made by prob. 16. of Spheric Trigonometry Geometrical.

1. For the opposite angle ACD, the proportion by Axiom 1. is thus:

As the sine of the side AC, is to the sine of the angle ACD, so is the sine of the side AD, to the sine of the angle ACD. That is;

S. side AC ·· S. angle ADC :: S. side AD ·· S. ang. ACD req.
S. 34d. 07m. ·· S. 27d. 30m. :: S. 65d. 20m. ·· S. 48d. 25m.

Which subtract from 180d. resteth 131d. 35m. for the angle ACD being obtuse.

2. For the contained angle CAD (having before found the opposite angle) the proportion by Axiom 2. Part 1. inverted is thus;

As the sine of half the difference of the sides AD and AC, is to the sine of half their sum; so is the tangent of half the difference of the angles ACD and ADC, to the tangent complement of half the angles CAD. And,

3. For the third side CD (having found the opposite angle) the Proportion by Axiom 3. Part 1. inverted is thus;

As the sine of half the difference of the angles ACD, and ADC, is to the sine of half their sum;

So is the tangent of half the difference of the sides AD and AC, to the tangent of half the side CD. That is;

	d. m.				d. m.		
Side AD	65·20			ang. ACD	131·35		
Side AC	34·07		d. m	ang. ADC	27·30		d. m.
Sum is	99·27	½	sum 49·43	sum is	159·05	½	sum 79·32
Differ.	31·13		diff. 15·30	diff. is	104·05		diff. 52·02

S. ½ diff. sides ·· S. ½ their sum :: T. ½ diff. angles ·· T. c. ½ CAD

S. 15d. 36m. ·· S. 49d. 43m. :: T. 52d. 02m. ·· T. c. 74d. 40m.

Which subtract from ——— 90d. 00m.

Remainder is ½ the angle CAD ——— 15d. 20m.

Which being doubled ——— 15d. 20m.

Produceth the required angle CAD ——— 30d. 40m.

S. ½ diff. angles ·· S. ½ their sum :: T. ½ diff. side. ·· T. ½ CD.

S. 52d. 02m. ·· S. 79d. 32m. :: T. 15d. 36m. ·· T. 19d. 12m.

Which being doubled ——— 19d. 12m.

Produceth the required side CD ——— 38d. 24m.

Prob. 8. case 4, 5, and 6.

Two angles, and one side opposite given; to find

1. The side opposite to the other Angle
2. The interjacent, or side between them
3. The third Angle ———

} if the required opposite side be foreknown to be more, or less than a quadrant.

Example. Plate 4. fig. 8.

In the oblique triangle ACD; there is given.

Given	Required
Angle CAD 30d. 48m.	Side AC less than 90d.
Angle ADC 27d. 30m.	Side AD
Side CD 38d. 38m	Angle ACD

This triangle is made by prob. 17. of Spheric Trigonometry Geometrical.

1. For the opposite side AC, the proportion by Ax. 1. is thus;

As the sine of the ang. CAD, is to the sine of the side CD, so is the sine of the ang. ADC to the sine of the side AC. That is,

S. Angle

S. angle CAD ·· S. ſide CD :: S. angle ADC ·· S. ſide AC req.
S. 30d. 48m. ·· S. 38d. 28m. :: 27d. 30m. ·· S. 34d. 06m.

2. For the interjacent ſide AD, (having firſt found the oppoſite ſide) the proportion by Ax. 3. Part 1. inverted is thus;

As the ſine of half the difference of the angles CAD, and ADC, is to the ſine of half their ſum;

So is the tangent of half the difference of the ſides CD and AC, to the tangent of half the ſide AD. And,

3. For the third angle ACD, (having firſt found the oppoſite ſide) the Proportion, by Axiom 2. Part 1. inverted is thus;

As the ſine of half the difference of the ſides CD and AC, is to the ſine of half their ſum;

So is the tangent of half the difference of the angles CAD and ADC, to the tangent complement of half the angle ACD. That is;

	d. m.		d. m.		d. m.		d. m.
Ang. CAD	30.48			ſide CD	38.28		
Ang. ADC	27.30			ſide AC	34.06		
Sum is	57.78	$\frac{1}{2}$	ſum 29.09	ſum is	72.34	$\frac{1}{2}$	S 36.17
Difference	03.18		diff. 01.39	differ.	04.22		D 02.11

S. $\frac{1}{2}$ diff. angles ·· S. $\frac{1}{2}$ their ſum :: T. $\frac{1}{2}$ diff. S. ·· Tc. $\frac{1}{2}$ AD.
S. 01d. 39m. ·· S. 29d. 09m. :: T. 02d. 11m. ·· T. 32d 38m.
Which being doubled — — 32d. 38m.
Produceth the interjacent ſide AD to be — 65d. 10m.
S. $\frac{1}{2}$ diff. ſides ·· S. $\frac{1}{2}$ their ſum :: T. $\frac{1}{2}$ diff. angles ·· Tc. $\frac{1}{2}$ ACD.
S. 02d. 11m. ·· S. 36d. 17m. :: T. 01d. 39m. ·· T. 24d. 14m.
Which ſubtract from — — — 90d. 00m.
Remainder is half the angle ACD — — 65d. 46m.
Which being doubled — — 65d. 46m.
Produceth angle ACD to be — — 131d. 02m.

Note. In the ſix preceding Caſes, the three given terms, without the quality of a fourth are not ſufficient, whereby one ſingle anſwer may be found; and the quality of the fourth is not always diſcoverable by the given terms: therefore they are called the ſix doubtful caſes.

Problem 9. caſe 7 and 8.

Two ſides and one angle between them given; to find
1. *Either of the other angles;*
2. *The third ſide, or ſide oppoſite to the given angle.*

Example. Plate 4. fig. 9.

In the oblique triangle ACD; *there is*

given	ſide AC	34d. 06m.	angle ACD or	required
	ſide AD	65d. 20m.	angle ADC and	
	angle CAD	30d. 46m.	ſide CD is —	

 This

This triangle is made by problem 18. of Spheric Trigonometry Geometrical, in page, 120.

For the angle ACD, or ADC, the proportion (by Axiom 2.) is thus;

	d. m		d. m.		
Side AD	65. 20	angle CAD	30.46		d. m.
Side AC	34. 06	the half is	15. 23	———	74. 37.
Sum of ſides	99.26	the $\frac{1}{2}$ ſum	49. 43	is com.	40. 17.
Differ. ſides	31. 14	the $\frac{1}{2}$ diff.	15. 37	———	74. 23.

As S. $\frac{1}{2}$ ſum AD & AC ·· S. $\frac{1}{2}$ their diff. :: T. c. $\frac{1}{2}$ CAD ·· T. $\frac{1}{2}$ diff. an.
As S. 49d. 43m. ·· S. 15d. 37m. :: T. 74d. 32m. ·· T. 52d. 02m.

Then again,

As Sc. $\frac{1}{2}$ ſum ſides ·· Sc. their diff. :: T. c. $\frac{1}{2}$ CAD ·· T. $\frac{1}{2}$ ſum angles.
As S. 40d. 17m. ·· S. 74d. 23m. :: T. 74d. 37m. ·· T. 79d. 32m.

To it add the half difference found above — 52d. 02m.
The ſum is the greater angle ACD — 131d. 34m.
And being ſubtracted, is the leſſer angle ADC——27d. 30m.

Note, If the ſum of the two contained ſides exceeds a ſemicircle, then ſubtract each ſide from 180 degrees, and proceed with thoſe remainders as with the ſides given; the proportion produces the complements of the angle required to a ſemicircle.

For the third ſide CD, or ſide oppoſite to the given angle, as alſo in caſe 10. following, the proportion (after the work above is done) may be made by Axiom 1. Or it may be deduced from the lord Napier's Catholick propoſition by a given perpendicular, let fall from one end of the leſſer given ſide, to the greater ſide given, reducing the oblique triangle, into two rectangulars) which finds the ſide oppoſite to the given angle at two proportions, without finding the angle; and it's thus,

1. As radius is to the ſine complement of the contained angle; ſo is the tangent of the leſſer given ſide to the tangent of a fourth arch.

Then, if the contained angle be acute, ſubtract the fourth arch from the greater given ſide, but when it is obtuſe from the ſupplement thereof to 180 degrees, the remainder is called the Reſidual Arch. Then,

2. As the ſine complement of the fourth arch is to the ſine complement of the Reſidual Arch;

So is the ſine complement of the leſſer given ſide, to the ſine complement of the ſide required. That is:

As radius ·· Sc. Angle CAD :: T. ſide AC ·· T. fourth arch
As S. 90d. ·· S. 59d. 14m. :: S. 34d. 06m. ·· T. 30d. 12m. Which being ſubtracted from the ſide AD———65d. 20m.
The remainder is the reſidual arch———35d. 08m.

As

As Sc. 4th arch -- S. c. resid. arch. :: S. c. side AC -- S. c. side CD.
As S. 59d. 48m. -- S. 54d. 52m. :: S. 55d. 54m. -- S. 51d. 35m.

Whose complement 38d. 25m. is the side CD required.

Note, When the contained angle, and residual arch, are each less, or more than 90 degrees, the side sought is less than a quadrant. But when one is more and the other less, it's more than a quadrant.

Problem 10. case 9 and 10.

Two angles and one side between them given,

To find { 1. *Either of the other sides?*
2. *The angle opposite to the given side?* }

Example, in the oblique triangle ACD; there is given,

The	angle ACD 131d. 34m.	side AC or,	required.
	angle ADC 27d. 30m.	side AD and	
	side CD 38d. 28m.	angle CAD is	

This triangle is made by problem 19. of Spheric Trigonometry Geometrical, in page 120. See plate 4. fig. 10.

For the side AC, or AD, the proportion (by axiom 3.) is thus;

Angle ACD 131. 34	The side CD 38. 28				
Angle ADC 27. 30	The $\frac{1}{2}$ is —— 19. 14				d. m.
Sum of angles 159. 54	the $\frac{1}{2}$	sum 79. 32	its com.		10. 28
Difference is 104. 04		diff. 52. 02			37. 58

As S. $\frac{1}{2}$ sum. ang. -- S. $\frac{1}{2}$ their diff. :: T. $\frac{1}{2}$ side CD. -- T. $\frac{1}{2}$ diff. sides
As S. 79d. 32m. -- S. 52d. 02m. :: T. 19d. 14m. -- T. 15d. 38m.

Then again,

S. c. $\frac{1}{2}$ sum ang. . S. c. $\frac{1}{2}$ their diff. :: T. $\frac{1}{2}$ side CD -- T. $\frac{1}{2}$ sum sides.
As S. 10d. 28m. . S. 37d. 58m. :: T. 10d. 14m. -- T. 49d. 45m.

To it add the half difference found above. —	15d. 38m.
The sum is the greater side AD — —	65d. 23m.
And being subtracted, is the lesser side AC —	34d. 07m.

Note, If the sum of the two given angles exceed 180 deg. then subtract each given angle from 180 degrees, and proceed with those remainders as with the angles given; the operation will produce each required side's supplement to 180 degrees.

For, the angle CAD, the angle opposite to the given side, the proportion (after the work above is done) may be by Axiom 1. Or from the Catholick Proposition (by a perpendicular let fall from the greater given angle to its opposite side) thus;

1. As radius, is to the sine complement of the interjacent side; so is the tangent of the lesser given angle, to the tangent of a fourth arch.

Then, if the interjacent side be more than a quadrant, subtract the fourth arch from the greater given angle, but when it's less, from the supplement thereof to 180 degrees, the remainder is the residual arch. Then,

2. As the ſine complement of the fourth arch, is to the ſine complement of the reſidual arch.

So is the ſine complement of the leſſer given angle, to the ſine complement of the angle required. That is;

As radius ·· S. c. ſide CD :: T. angle ADC ·· T. 4th arch.
As S. 90d. ·· S. 51d. 32m. :: T. 27d. 30m. ·· T. — 22d. 10m.
which ſubtract from (the ſuppl. of the ang. ACD)— 48d. 26m.

The remainder is the reſidual arch — — — 26d. 16m.

Then,

S. c. 4th arch ·· S. c. reſid. arch. :: S. c. ang. ACD ·· S. c. ang. CAD req. S. 67d. 50m. ·· S. 63d. 44m. :: S. 62d. 30m. ·· S. 59d. 12m. whoſe complement 30d. 48m. is the angle CAD required.

Note, Then the interjacent ſide and reſidual arch, are each leſs, or each more than 90d. the angle ſought is acute; but when one is more and the other leſs, it's obtuſe.

Problem 11. caſe 11. *Three ſides given to find either of the angles.*

Example. Plate 4. fig. 1.

In the oblique triangle ACD there is given,

The ſide	AD 65d. 20m. / CD 38d. 26m. / AC 34d. 08m.	angle	ACD, or / ADC, or / CAD, required?

This triangle is made by Problem 20. of Spheric Trigonometry Geometrical, in page 120, 121.

The reſolution of this and the following caſe depends upon Axiom 4. and for the more ſpeedy ſolution, obſerve theſe directions, *viz.*

1. Add the three ſides together, and from their half ſum ſubtract the ſide oppoſite to the angle required, nothing the remainder.

2. To the complement arithmetical of the log-ſines of the containing ſides, add the log-ſines of the half ſum and the remainder: half the total of theſe 4 logarithms, is the log-ſine of half the required angle's ſupplement of 180 degrees.

The operation of the angle ACD, is thus;

	d. m.		
Side CD	38. 26	the containing ſides	S. co. ar. 0.206487
Side AC	34. 08		S. co. ar. 0.250944
Side AD	65. 20	½ ſum ſides 68d. 57m. S. —	9.970006
Sum is	137. 54	remainder is 4d. 37m. S. —	8.799897
½ Sum is	68. 57	ſum of the 4 logarithms is —	19.227334
Remain.	3. 37	24d. 15m. S. ½ ſum	9.613667

Double it — — — — 24d. 15m.
The ſum is — — — — 48d. 30m.
Which ſubtract from — — 180d. 00m.
Remainder is the angle ACD 131d. 30m.

In

In like manner you may find any other angle by logarithms,

But by Gunter's scale say,

1. As radius, is to the sine of one of the containing sides;
So is the sine of the other containing side to a fourth sine.

Then,

2. As that 4th sine is to the sine of the half sum of the three sides,
So is the sine of the remainder, to a fifth sine; against which on the line of versed sines is the angle required.

That is,

As radius ·· S. side CD :: S. side AC ·· a fourth sine.
As S. 90d. ·· S. 38d. 26m. :: S. 24d. 08m. ·· S. 20d. 26m.

Then again,

As fourth sine ·· S. ½ sum sides :: S. remainder ·· a fifth sine.
As S. 20d. 26m. ·· S. 68d. 57m. :: S. 03d. 37m. ·· S. 9d. 43m. against which on the line of versed sines, is 131d. 30m. the angle ACD as before.

Problem 12. case 12. *The angles given to find a side.*
Example. Plate 4. fig. 12.

In the oblique triangle ACD; there is given the

Angle	ACD 30d. 47m.		side	CD, or
	ADC 27d. 30m.			AC, or
	CAD 131d. 34m.			AD, required.

This triangle is made by Problem 21, Spheric Trigonometry Geometrical, in page 121.

This case is likewise performed by the directions in case 11. the angles being accounted sides, and the sides angles; and then taking the supplement of the greater (given) angle to 180 degrees.

For the side AD, the operation is thus;

	d. m.		
Sup. an. CAD	48 26	the adjacent angles S. co. ar.	0.125992
Angle ADC	27 30	S. co. ar.	0.335595
Angle ACD	30 47	½ sum ang. 53d. 21m. S. ——	9.904335
Sum is	100 43	remainder 22d. 34m. S. ——	9.584057
½ Sum is	53 21	sum of the 4 logarithms is	19.949979
Remainder	22 34	———— 70 45 S. ½ sums	9.974989

Double it — — 70 45
The sum is — — 141 30 which
Subtract from — 180 00
Remainder is the side AD 38 30

In like manner may any other side be found by logarithms;
Or this; By

By Gunter's ſcale.

1. As radius, to the ſine of one of the adjacent angles (to the ſide required) ſo is the ſine of the other adjacent angle to a fourth ſine.

2. Then as a fourth ſine, is to the ſine of half the ſum of three angles;

So is the ſine of the remainder, to a fifth ſine; againſt which, on the line of verſed ſines, is the ſide required.

That is,

As radius ⁚ S. ſup. CAD :: S. angle ADC, a fourth ſine

As S. 90d. ⁚ S. 48d. 26m. :: S. 27d. 30m. ⁚ S. 20d. 13m.

Then again,

As fourth ſine ⁚ S. ½ ſum angles :: S. remainder ⁚ a fifth ſine

As S. 20d. 13m. ⁚ S. 53d. 21m. :: 22d. 34m. ⁚ S. 20d. 13m.

againſt which on the line of verſed ſines is, ——— 38. 30m. the ſide AD as above.

Note; When the greater ſide (CD, which ever is oppoſite to the greater angle) is required, the operation will produce the ſupplement thereof to a ſemicircle; wherefore if it be ſubtracted from 180d. it leaves the ſide ſought: or by the logarithms) if you omit this part of the operation (which ſubtract from 180 degrees, &c.) you have the ſide required.

So much for the doctrine of Spheric Triangles; the application follows.

CHAPTER VI.

Containing the deſcription and uſe of the GLOBES.

HAving finiſhed Spheric Trigonometry, it remains to ſhew its uſes in Geography, Great Circle-Sailing, and Aſtronomy; in order to the perfect underſtanding of theſe, it's requiſite firſt to be acquainted with the Nature and Uſes of the Globes, which I will endeavour to perform briefly and plainly.

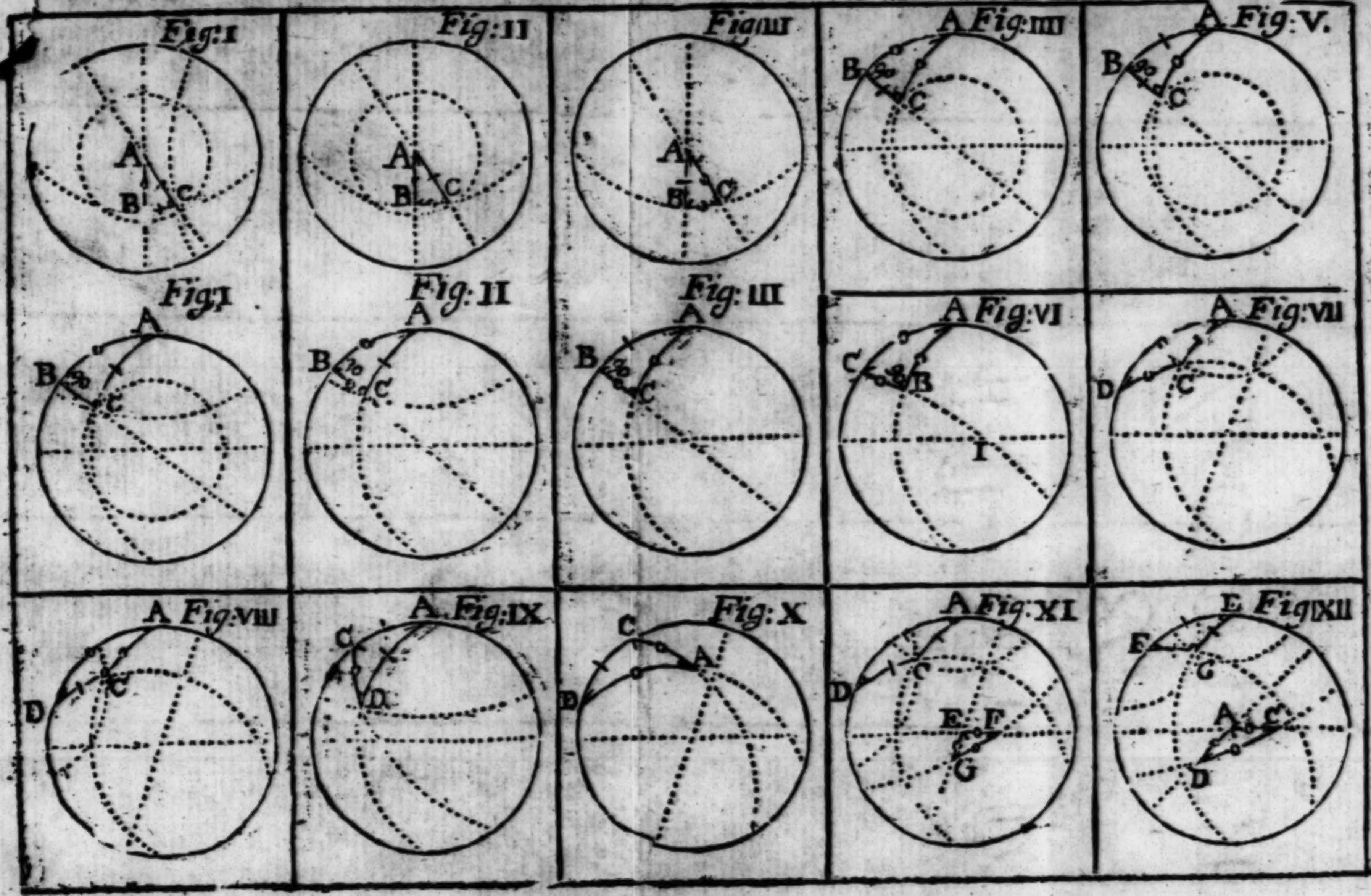
Section I. *The deſcription and uſe of globes in general.*

1. A Globe, as to its name and figure is ſo generally known that its needleſs here to produce a mathematical definition of it; but as to the kinds of material globes, and their parts, it is neceſſary ſomething ſhould be ſaid.

2. The kinds of globes are two, terreſtrial and cœleſtial, which together with their appurtenances, are for the lively repreſentation

Plate 4.

Place this next after Page 138.



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representation of the natural situation and position of the earth, and heavens, and are useful for the demonstrating (by representation and resolution of any problem belonging to the sphere of heaven or earth, either in Geography, Navigation, or Astronomy.

3. The appurtenances appertaining to material globes are six; the body or globe itself, brazen meridian, quadrant of altitude and its screw, hour circle and index, wooden frame or horizon, and brass semicircle of position, all may be used with either globe; yet the last being of least use may be supplied by the quadrant of altitude.

4. The body or globe itself, is an emblem of heaven, or of earth; on which are drawn divers lines, and circles; useful and proper for the understanding them.

5. The Brazen Meridian, is the ring in which the globe hangeth, and turneth upon its axis, being two wires, issuing forth its body; and is divided into four Quadrants, each 90 degrees, and figured 10, 20, 30, &c. to 90.

6. The Quadrant of Altitude, is a narrow thin slip of Brass, with a notch, nut and screw at one end; it's divided into 90d. which shew the almicanthers, or circles of altitude, and the edge represents an azimuth circle.

7. The Hour Circle, is a flat ring of brass, so contrived that it may be took off, and fixed about either pole of the globe; its divided into 24 hours of a natural day, each hour is divided in halves and quarters; to this belongs an index, having a round hole at one end, to put it on the Axis of the Globe.

8. The Wooden Frame, or Horizon, is round and flat; in which the brazen meridian doth move through two notches, in the upper part; another in the middle of the bottom of it: On the upper part is a Kalendar, shewing the day of the month, sun's place in the ecliptic, the rumbs or points of the compass, &c.

9. The Circle of Position is a semi-circle of brass, the upper side is divided into 180 degrees, it serveth to measure distances either on the terrestrial or cœlestial globe.

Section II. *The description and use of the* Terrestrial Globe.

THE Terrestrial Globe hath on the superficies of its body, the whole form and fashion of the earth and sea, described; with the circles of the sphere, as equator, meridians, tropics, &c.

In order to a clear understanding the use of this globe, observe these following geographical definitions.

1. The Earth, together with the water, composeth that round body called the Orb, or globe of the earth, which is described by lines real and imaginary.

2. The

2. The Real Lines are such as agree to the terrestrial Globe, by nature, and so divide it into continents, islands and seas; the imaginary parts, are such as are applied to it by virtue of our understanding; and being not materially such, are supposed to be on the earth, these imaginary lines are either straight or circular.

3. The Axis, is a straight line imagined to pass through the Center of the Earth; the extream points are the poles on which the world is supposed to move; one called the Artic or North-Pole, the other the Antartic or South-Pole; it's represented by the wires on which the globe turneth.

4. The Circular Lines are either greater, as the Meridian, Horizon, Æquator; or lesser, as Tropics, Polar, Circles, Parallels of latitude.

5. Meridian, is a circle passing through the poles of the earth, the zenith and nadir crosseth the æquator at right angles, and divideth the earth into two equal parts; one east the other west. It's so called because when the sun cometh to the meridian of any place, it's then noon, or mid-day there; they are infinite in number, for that all places from east to west have their several meridians.

Of these one is called the First, or Chief Meridian, from which the longitude of places is reckoned; it's of special note and use, but variously placed by Geographers: it's represented on the globe by a double line passing through the poles, and is divided into twice 90 degrees, numbred from the æquator towards each pole, ending there in 90 degrees.

6. The Horizon is that circle which comprehendeth all that space of the earth which is visible, and distinguisheth it from that (lying under the horizon) being invisible; it's either sensible or rational.

The Sensible Horizon, is that apparent circle which extends it self in a straight line from the place we stand upon, and round about us, dividing the heavens into two unequal parts; and being limited by the sight, is sometimes greater or lesser, according to the condition of the place, &c.

The Rational Horizon, is a circle dividing the heavens into two equal parts, passeth through the center of the earth, whose poles are the zenith and nadir. By this circle our days and nights are measured, and the divers risings and setting of the sun, moon, and stars doth appear: it's represented on the globe by the upper part of the Wooden Frame.

Note; The Meridian and Horizon; are moveable with the mutation of places.

7. The Æquator, is a line under the equinoctial in the heavens, compassing the earth in the middle between its two poles, dividing it into two equal parts, called the northern, and southern

thern hemispheres; from it the latitudes of places are reckoned, either north or south: this circle is represented on the globe by a double, or treble line, divided into 360 degrees, and numbred 10, 20, 30, &c. from the left-hand towards the right, till it end in 360 degrees.

This circle is called Æquator, because when the sun comes to it, which is twice a year (*viz.* about the 10th of March, at his entrance into Aries; and again into Libra, about the 12th of September) he makes equal days and nights throughout the world. And upon it is writ in capital letters Linea sub Æquinoctiali.

8. The Lesser Circles, described on globes, are called Parallel Circles, some of which have particular names, as Tropics and Polar Circles.

9. The Tropics are two, being parallel to the equator, and distant from it 23d. 30m. That on the north side of it, is called the Tropic of Cancer, at which the sun hath his greatest north declination: then making to us (and all places in north-latitude) the longest day, and shortest night; which is about the 11th of June: the other on the south-side, is called the Tropic of Capricorn, at which the sun hath his greatest south declination, making then our shortest day and longest night, which is about the 12th of December. These Tropics have their names thus; Tropicus sub Cancro, and Tropicus sub Capricorno.

10. The Polar Circles are two, being also parallel to the æquator, and compassing the poles of the world at 23d. 30m distance: that about the north-pole is called the Artic Circle, and the other the Antartic Circle, and are writ thus; Circulus sub Artico Polo, and Circulus sub Antartico Polo.

These Tropics, and Polar Circles divide the globe of the earth into five parts, called Zones: of which three were accounted by the ancients to be so intemperate as to be uninhabitable calling them Torrid, Frigid, and Temperate; that is one Torrid or burning Zone, two Temperate, and two Frigid or frozen Zones.

11. The Torrid Zone, is that which lieth between the two Tropics of Cancer and Capricorn.

12. The two Temperate Zones are contained between each Tropic, and a Polar Circle.

13. The two Frigid Zones are contained within each Polar Circle; that is, one within the Artic Circle, and the other compassed by the Antartic.

Thus much of the Imaginary Lines, and parts of the earth: the real parts, are earth and water, in general divided into four parts or quarters; called Europe, Asia, Africa, and America; each of these, and consequently the whole globe, is divided into continents, islands, and seas.

14. A Continent, is a greater quantity of land, not divided by the ſea, wherein are many kingdoms, and countries conjoined: as Europe, Aſia, and Africa in one continent, and America is another.

15. An Iſland, is a part of the earth that is environed or compaſſed round by Water; as Great-Britain, and alſo Ireland, &c. are iſlands.

In Continents, and Iſlands, are theſe parts obſervable; *viz.* Peninſula, Iſthmus and Promontory.

16. Peninſula, is ſuch a part of land as is almoſt environed round with water, and is joined with the land by an Iſthmus, as the Morea in the Levant.

17. An Iſthmus, is a narrow neck of land between two ſeas, which joineth the Peninſula to the Continent; as Corinth in Greece.

18. A Promontory is a high hill, mountain, or cape of land that ſhooteth it ſelf into the ſea; as Cape de Verde, and the Cape of Good Hope in Africa.

19. A Place in reſpect to the Heavens, is either eaſt, weſt, north or ſouth.

Thoſe places are ſaid to be eaſt, which lie in the eaſtern hemiſphere (terminated by the firſt meridian) or where the ſun riſeth.

And thoſe are weſt which lie weſterly of the ſaid meridian, or towards the ſetting of the ſun.

Thoſe places are properly north, which lie betwixt the æquator and the artic pole.

And thoſe places are ſouth, which lie betwixt the æquator and the antartic pole.

The ancients have divided the inhabitants of the earth into Periæci, Antiæci, and Antipodes.

20. The Periæci, are ſuch as live under the ſame parallel but in oppoſite points of it; that is, they are in the ſame latitude, but their difference of longitude is 180 degrees.

21. The Antiæci, are ſuch as have the ſame meridian and equally diſtant from the equator, but the one north, and the other ſouth: that is; two places in one longitude, and each equal in latitude; one in north and the other in ſouth latitude.

22. The Antipodes, are ſuch as inhabit two places of the earth, which are diametrically oppoſite one to the other: that is, two places, whoſe difference of latitude and longitude, is each 180 degrees, and ſuch walk feet to feet.

The Earth being encompaſſed with Water, whoſe waſhings in ſurrounding the dry land, cut out and ſhape many winding Bays, Creeks, meandring Inlets, giving terminations to the four regions of the earth, and extending it ſelf round them all, is but one continued ocean. Wherefore,

The Water is either Ocean, Seas, Straits, Creeks, Lakes, Rivers, or Bays, &c.

23. The

23. The Ocean, is a general collection or rendezvous of all Waters.

24. The Sea is a part of the ocean, to which we come through some straight; as the Mediterranean and Baltick Sea.

25. A Strait, is a narrow part of the ocean, lying betwixt two shoars, and opening a way into some sea; as the Straits of Gibraltar, that lead into the Mediterranaen Sea; and the Sound, which leadeth into the Baltic-Sea.

26. A Creek, is a small narrow part of the sea, or river that goeth up but a little way into the land.

27. A Bay is a great inlet of the land, as the Bay of Biscay and the Bay of Mexico: otherwise a bay is a station, or road for ships to anchor in.

28. A River, is a small branch of the sea, flowing into the land, courting the banks, whilst they their arms display, to embrace silver waves.

29. A Lake, is that which continually retains and keeps water in it, as the lake Zaire in Africa, and lake Nicurgua in America.

30. A Gulf, is an inlet of the land, deeper than a bay, as the Gulf of Venice, the Gulf of Florida; in which are swift Currents.

Of the names of the Ocean.

31. The Ocean, according to the four quarters had four names; as the Eastern or Oriental Ocean, the Western or Occidental Ocean, the northern, or Septentrional, and the Southern or Meridional Ocean. But besides these, it hath other particular names according to the continent it boundeth, and the nature of the sea. As it lies extended towards the east, it's called the Chinean Sea, from the adjacent country of China: towards the south it's called Oceanus Indicus, or the Indian-Sea, where it washeth the coast of Persia, it's called Mare Pacificum, in like manner Mare Arabicum from Arabia; and so towards the west, it's the Ethiopian Sea.

Then the Atlantick Ocean, from Atlas, a mountain in Africa: but near to America, its called by the Spaniards, Mar-del-Nort; and on the other side of America, its Mar-del Zur, or Mare-Pacificum.

Where it toucheth upon Spain, it's Oceanus Hispanicus, by the English, the Bay of Biscay: between England and France, its called the English Channel: between England and Ireland, the Irish Sea, or St. George's Channel: between England and Holland, by some the German, but rather the British Ocean: northwards of Scotland, its called Mare Caledonium: more northerly, it's the Hyperborean or Frozen S: more easterly, it's the Tartarean Sea, or Scythian Ocean, &c. Thus for the names of the ocean. Next,

Of the names of the seas.

32. The Baltic Sea, by the Dutch the Ooſt Zea, lying between Denmark, Sweden, and Germany, whoſe entrance is called the Sound: the Mare Mediterranean, by the Engliſh the Straits; by the Spaniards, Mar-de-Levant; the entrance whereof is called the Straits of Gibraltar: then Pontus Euxinus, or the Black Sea; to which joins Meotis Palus, now Mar-del-Zabecke: then the Caſpian, or Hercanean-Sea: then the Arabian Gulf, Mare Rubrum, or the Red-Sea: and the Perſian Gulf, or Gulf de Elcatiff, &c.

Of the diviſion of the earthly globe.

33. The globe of the earth (as was ſaid before in Def. 13.) is divided into four parts, *viz.* Europe, Aſia, Africa, America.

34. Europe is bounded towards the north by the Northern Ocean or Frozen Sea; on the ſouth by the Mediterranean Sea, lying betwixt it and Aſia; on the eaſt with the river Tanais: and on the weſt by the weſtern, or Atlantic Ocean; whoſe chief provinces are,

Poland,	Muſcovia,	Sweden,	Norway,
Denmark,	Germany,	France,	Spain,
Portugal,	Italy,	Hungary,	Sclavonia,
Greece,	Dalmatia,	Romania,	part of Tartariæ.

The principal iſlands are,

Great-Britain,	Ireland,	Sardinia,	Sicily,
Corſica,	Candia,	Negropont,	Cyprus.

35. Aſia is bounded in the north with the northern and Tartarian Ocean; in the ſouth with the Arabian Gulf, or Red-Sea; on the eaſt with the Indian Ocean; on the weſt with the river Tanais.

The chief regions are,

Turkey in Aſia,	Arabia,	Tartaria,	Perſia,
Anatolia,	Meſopotamia,	Aſſyria,	Chaldea,
Syria,	Armenia,	Paleſtina,	Georgia,
Media,	Parthia,	China,	India.

The principal iſlands are,

Japan,	Sumatra, Borneo, &c. in the Oriental Ocean.
Cyprus,	Rhodes, in the Mediterranean.
Metellino,	Scio, Samos, &c. in the Archipelagus.

36. Africa is bounded on the north with the Mediterranean, on the eaſt with the Red-Sea, on the ſouth with the Æthiopian or Southern Ocean, and on the weſt, with the Atlantic Ocean.

The principal provinces are

Egypt,	Barbary,	Billedulgerid.
Deſarts of Sarra,	Negroland,	Æthiopia, or Abyſſine.
Nubia,	Monomotapa.	

Its principal iſlands are,

The Canary iſlands,	Cape de Verde iſlands.

The

The isles of Azores, Madera islands,
St. Thomas, Madagascar, or St Lawrence.
Malta, in the Mediterranean.

37. America, is bounded on the north with the northern Ocean, on the east with the Atlantick Ocean, on the south with the Magellantick-Sea, and on the west with the south sea, or Mar-del Zur, its divided into two parts, *viz.* Mexicana, and Peruana.

Mexicana, or North-America hath these provinces,

New-Spain, Terra Florida, Carolina, Virginia, and Maryland, Pensilvania, New-Jersey, New-York, New-England, New-France, Greenland, whether continent or island is not yet known.

The chief islands of Mexicana are,

Island, or Ice-land, California, New-found-land, Bermudas.

Peruana, or South-America, hath these provinces;

Terra Magellanica, Brazilla Chili. The Amazons, Guianea, Peru, Panama, Cathagena, Peraguay, or Rio-de-la-Plata.

The principal islands of Peruana are,

Hispaniola, Cuba, Jamaica, Port-Rico, Barbadoes, and the rest of the Caribbee-Islands, &c.

Moluque Islands, Java-Major, Java the less, and many other islands in the east-indies.

Having discribed the lines and circles, and the parts belonging to the Terrestrial Globe, the uses of all take in the following problems.

Problem 1. *To find the latitude of any place on the globe.*

The rule. Bring the proposed place just under the Brass Meridian, and note what degree (on the said meridian) stands against it, which is the latitude thereof. Or thus,

With a pair of compasses, take the nearest distance from the proposed place (on the globe) to any parallel of latitude, and lay it on the graduated or first meridian, from the said parallel, the same way the proposed place lyeth from it, the other foot sheweth the latitude required.

Example. *Let it be required to find the latitude of the* Lizard *in* England.

Turn the body of the globe till the Lizard be just under the brass-meridian, and you'll find 50 deg. right against it, which is the latitude of the Lizard.

Take the nearest distance (on the globe) from the Lizard, to a parallel of latitude, apply it to the graduated meridian, and it sheweth the latitude 50 degrees as before. Or thus,

Note, All those circles on the globe, which are parallel to the æquator, are called parallels of latitude.

Problem 2. *To find the longitude of any place on the Globe.*

The rule, 1. Turn (as before) the globe till the propoſed place lie juſt under the braſs meridian, and there keep it ſteady.

2. Then obſerve what degree of the æquator lieth under the braſs meridian, and that's the longitude required.

Example. *I demand the longitude of the* Lizard *in* England?

Bring the Lizard under the braſs meridian, and then the braſs meridian cutteth the æquator into 90d. 56m. longitude required.

Note, The globes formerly made in England begun longitude at the meridian of the iſland of St. Michael one of the iſles of the Azores; which is weſt from the meridian of London (according to the Mariner's Compaſs rectified, (25d. 20m.

And accordingly the Lizard's longitude is 5d. 24m. weſt from London: this difference in the longitude of places, is occaſioned by the different beginnings of longitude by ſeveral authors, which the ſtudent is deſired to conſider.

Problem 3. *To find the diſtance of any two places on the globe.*

The rule, 1. Lay the beginning of the degrees on the quadrant of altitude, upon one of the propoſed places, and count how many degrees on it, are contained between both places, which is the diſtance required.

2. Thoſe degrees being multiplied by 60, the product is the diſtance in minutes. Or thus,

Take the diſtance between the two places, with a pair of compaſſes, then meaſure that diſtance on the æquator, counting the degrees intercepted between both feet, and it will ſhew the diſtance required.

Note; The diſtance found by this problem, is the ſhorteſt diſtance: or their diſtance in the arch of a great circle, which is leſs than their diſtance in the rumb, leading from one to the other; except both places lie under one meridian, or in the æquator.

Example. *I demand the diſtance between the* Lizard *and the iſland* Barbadoes?

If you lay the edge of the quadrant of altitude on both places, and the beginning of the degrees of it on one of the places, you will find on the quadrant of altitude 56 degrees intercepted between them, which is the diſtance; and being multiplied by 60, is 3360 miles or minutes.

Problem 4. *To find the angle of poſition of a place; that is, the angle the arch of a great circle paſſing through two given places makes with the meridian of either of them.*

The

The rule, 1. Rectify the body of the globe to the latitude of one of the given places.

2. Bring the same place under the brass meridian, and there stay the body of the globe.

3. Screw the quadrant of altitude fast to the brass meridian, right over the said place.

4. Then lay the graduated edge of the quadrant of altitude to the other place, and the said edge will cut the horizon in the degree of position required.

Example. *Let it be required to know the angle of position of* Barbadoes *from the* Lizard.

1. Bring the Lizard to the brass meridian, and there staying the body of the globe, you will find the latitude of the Lizard, to be 50 degrees.

2. Move the brass meridian (keeping the body of the globe fixed as before higher or lower until 50 degrees on it do cut the horizon (on the north side thereof) then is the globe rectified to the latitude of the Lizard: the like you must do in rectifying the globe for any other place or latitude.

3. Screw the quadrant of altitude to 50 degrees on the brass meridian (which is just over the Lizard, if the globe be not turned from its position as in the first step hereof) and turn the graduated edge of it to Barbadoes, the said edge will point on the horizon to 71d. 30m. south westerly; which is the angle of position of Barbadoes, from the Lizard; that is, the angle the arch of a great circle passing through or over the two places, makes with the meridian of the Lizard, which is not the rumb, leading from the first to the second: for if you rectify the globe to the latitude of Barbadoes, and so proceed as before directed, you will find the angle of position to be 37d. 30m. north-easterly, the position of the Lizard from Barbadoes, which is 34 degrees less than the position of Barbadoes from the Lizard, whereby it appears, neither of these are the true rumb or point of the compass leading from one to another. For you are to Note;

1. That the rumb-lines or points of the compass, make equal angles with all meridians on the globe.

2. That an equal segment, or part of the said rumb, changeth or altereth the latitude in all places equally.

3. That the rumb-lines, tho' continued never so far, do not pass through the poles, but wind about them till they lose themselves.

4. These rumb-lines are represented on the globe by those spiral lines, that you see are 32 in number, meeting in a center, where there is a Flower-de-Luce pointing to the north; from thence they run winding about the globe, and continue inclining towards the pole, where they seem confused.

Problem 5. *Two places being given; to find their rumb or course of bearing, or sailing from one to another.*

The rule, 1. Having found the two places on the globe, see what rumb-line passes through both of them, and that is the rumb or course from one to another.

2. If no rumb-line passes through both places, then look what runneth parallel to both places, and that is the rumb, or course from one to another.

Example 1. *I demand the course from the* Lizard *to* Cape-Cod in New-England?

On the globe you will find these places to lie on the W. by S. and E. by N. rumb-lines, and therefore the course from the Lizard to Cape-Cod, is W. by S. and consequently from the last to the first, E. by N.

Example 2. *I demand the course from the* Lizard *to island* Barbadoes?

Here is no rumb-line on the globe passing thro' them, wherefore look for a rumb to which the place lies most parallel, and you'll find it S.W.½W. the course from the Lizard to I. Barbadoes; and N.E½E, from I. Barbadoes to the Lizard.

Problem 6. *Course and distance sailed being given; to find the difference of latitude, and difference of longitude.*

The rule 1. Make a small mark on that rumb-line (which is the given course) in the latitude of the place you sailed from, and bring that mark to the brass meridian, which cuts the æquator in its longitude.

2. Take the distance sailed from the æquator, and lay it on the said rumb, for the foresaid mark; at the termination thereof make another mark.

3. Then bring the second mark to the brass meridian, there is the latitude of that place; and then the meridian cuts the æquator in the longitude of it.

4. Having the latitude and longitude of those two places marked in the rumb-line, by subtraction you may find their difference of latitude and difference of longitude, and it's done.

Examp. *Suppose a ship sails* SW. *by* W. 200 *leagues, or* 10 *degrees from the* Lizard: *I demand her distance of latitude, and difference of longitude: or what latitude and longitude she is in?*

1. I make a mark on the S.W. by W. rumb, just under 50 degrees (the Lizard latitude) and then the meridian cuts the æquator in 357 degrees, the longitude of that mark.

2. Take 10 degrees from the æquator, and lay it on the S. W. by W. rumb, from the first mark to a second mark.

3. Bring

3. Bring this second mark to the brass meridian, and there the latitude of it is 44d. 50m. the latitude the ship is in, and in the æquator the longitude of it is 344d. 15m. and by subtraction, the difference of latitude is 5d. 20m. and difference of longitude required is 12d. 54m. But here you must note,

That the distance sailed entirely taken and laid on the rumb, is the distance in the arch of a great circle and not really in the rumb; for the distance in the great circle is always less than the distance in the rumb; wherefore the better way will be, to take 1. 2. 3. (or some small number of) degrees of the æquator; and run that distance (in the compasses) over upon the rumb-line, from the first mark to the second; and in so doing, the distance is more truly laid than by taking it at once.

Problem VII. *Both latitudes and course given, to find the distance and difference of longitude.*

The rule. Turn the body of the globe till the given rumb doth cut the brass meridian in the latitude you depart from, and there make a mark on the rumb, and at the same time see what degree of the æquator is cut by the meridian; for that is the longitude of this mark.

2. Turn the body of the globe, till the same rumb cuts the meridian in the latitude of the second place, and there make another mark on the rumb; then see what degrees of the æquator is cut by the meridian, which is the longitude of the second mark; and the lesser longitude subtracted from the greater, gives the difference of longitude required.

3. The distance between the two marks on the rumb-line being measured (according to the note in the last problem) on the æquator, gives the distance of the two places.

Example. *If a ship sails S. W. by W. from the* Lizard, *till by observation she be in latitude 44d. 50m. north; I demand her distance sailed, and what longitude she is in?*

1. When you bring the S. W. by W. rumb to cut the meridian in 50d, the Lizard's latitude, and make a mark on the rumb, there, then the meridian cuts the æquator in 357d. the longitude of that mark.

2. Turning the globe till the S. W. by W. rumb cuts the meridian in 44d. 50m. the latitude of the second place, and making there a mark on the rumb: then the meridian cuts the æquator in 344d. 15m. the longitude of the second mark: and therefore the Difference of Longitude, is 12d. 45m. west; which being subtracted from the longitude of the Lizard: 20d. 00m. the remainder is 07d. 15m. the longitude the ship is in.

3. Take 2 degrees from the æquator, and run over that distance in the compasses upon the rumb, from the first mark to the second; and its five times, which is 10d. or 200 leagues, the distance sailed on that rumb.

Prob. 8. *Having the latitude and longitude the ship is in given; to find the place where the ship is in on the globe.*

The rule. 1. Bring the longitude to the brass meridian, and there stay the body of the globe.

2. Where the given latitude cuts the globe, make a mark on the body of the globe, which mark is the place of the ship at that time.

Example. *If a ship sails from the* Lizard, *and after some time is in latitude 44d. 50m. and longitude 9d. 45m. I demand the place of the ship on the globe.*

1. Bring 9d. 45m. on the æquator to the brass meridian, and there stay the globe.

2. Just under 44d. 50m. on the brass meridian, make a mark on the body of the globe, and that is the place of the ship at that time.

Section III. *The description of the* Cœlestial Globe.

THE Cœlestial Globe represents that glorious canopy, so richly embroidered, and beset with those sparkling diamonds, that upon the dusky cheeks of the night hang as a rich jewel as in an Ethiopian's ear; having upon its convexity artificially placed all the stars, correspondent to their natural situation in the concavity of that orb, we call the Starry Heaven.

2. The appurtenances belonging to this, are the same with those belonging to the Terrestrial Globe; and being before described in section 1. of this chapter, I refer you to it.

3. On the body of the globe, besides the constellations of the stars there are drawn divers circles; as the Equinoctial, Ecliptic, Colures, Meridians, and Circles of longitude; all these are called great Circles; the lesser circles are the Tropics, Polar Circles, and Parallels of declination.

4. The Equinoctial in this, is the same with the equator in the Terrestrial Globe, and in the same manner divided; and numbred from the left hand towards the right with 10, 20, 30, &c. to 360 degrees.

The poles of the equinoctial are also called the poles of the world, and are represented by the two wires on which the body of the globe turneth.

5. The Ecliptic is a great circle which crosseth the equinoctial in two opposite points; the beginning of Aries, and Libra; its divided into twelve (equal parts) called signs, each containing

taining 30 degrees, and figured from the left hand towards the right, 10, 20, 30; then 10, 20, 30, &c. having the figure, character, and names of the ſigns, as followeth:

Aries	♈	northern ſigns	Libra	♎	ſouthern ſigns
Taurus	♉		Scorpio	♏	
Gemini	♊		Sagittarius	♐	
Cancer	♋		Capricornus	♑	
Leo	♌		Aquarius	♒	
Virgo	♍		Piſces	♓	

This circle with its figures and characters, are on both globes; but the cœleſtial hath the image and name of the ſigns which the terreſtrial hath not.

Under this circle the ſun moves in his annual courſe; but the reſt of the planets have their deviations from it; for which reaſon Aſtronomers aſſigned eight degrees on each ſide the ecliptic, making the whole latitude to be 16 degrees, which breadth is called the zodiac.

The Zodiac, is not drawn on the globe, only imagined by two circles parallel to the ecliptic, at eight degrees diſtance from it on each ſide thereof.

The Poles of the Ecliptic, are two oppoſite points, each 23d. 30m. diſtant from its correſpondent Pole of the World; there the circles of longitude meet, and near it, is writ Polus Eclipticæ.

6. The Meridians are the ſame as was ſaid in the Terreſtrial Globe, only with this difference, on this they are drawn through every 30th degree of the equinoctial, on that through every 15th degree of the equator; in both they all meet in the poles of the world.

7. The Colures, or the two meridians cutting each other at right angles in the poles of the world, dividing the equinoctial, and ecliptic into 4 equal parts; the one paſſing by the beginning of Aries and Libra, two equinoctial Signs, therefore called the Equinoctial Colure: and on the globe it is divided into degrees, numbered from the equinoctial both ways, 10, 20, 30, &c. ending in 90 at each pole of the world; it hath theſe words near it, Colurus Equinoctiorum.

The other paſſeth through the beginning of Cancer and Capricorn, two Solſtitial Signs, therefore called the Solſtitial Colure: this paſſeth through the poles of the world, and poles of the ecliptic; its diſtinguiſhed on the globe by theſe words, Colurus Solſtitiorum.

8. The Horizon, is a great circle 90d. diſtant from the zenith, and nadir, cutting all azimuth circles at right-angles, and divideth the world into two equal parts, the upper and vi-

ſible hemiſphere, the lower and inviſible; its repreſented by the upper ſide of the wooden frame, on which is a double kalendar, of months and days, according to the old and new ſtile, with the winds or points of the compaſs, and a circle of ſigns and their degrees.

The zenith and nadir, are two points diametrically oppoſite, and they are the poles of the horizon. The zenith is the Vertical Point, or point over our head, the nadir is directly oppoſite thereto.

9. The Azimuth or Vertical circles, are great circles interſecting each other in the zenith and nadir, and cutting the horizon at right-angles: theſe circles are not drawn on the body of the globe, but are repreſented by the quadrant of altitude, when its ſcrewed in the zenith.

10. Circles of Longitude, are great circles interſecting each other in the poles of the ecliptic, and cut it at right-angles: theſe are repreſented by the quadrant of altitude when it is ſcrewed over the poles of the ecliptic: and on the body of ſome globes, 12 of theſe circles are drawn, paſſing through the beginning of the 12 ſigns.

Thus much for the great circles. We paſs on to

The deſcription of the leſſer circles.

Leſſer or ſmall Circles, are thoſe which divide the globe into two unequal parts, and are parallel to ſome great circle, therefore called Parallel Circles, and are of three kinds, *viz.* Parallels of Declination, Parallels of Altitude, and Parallels of Latitude.

11. Parallels of Declination, are parallel to the equinoctial, imagined to paſs through every degree and minute of the meridian, between the equinoctial and each pole of the world; and are the ſame with parallels of latitude on the Terreſtrial Globe.

The Tropics and Polar-Circles, are parallels of declination, and the ſame as before in the deſcription of the Terreſtrial Globe.

12. Almicanters, or Parallels of Altitude, are parallel to the horizon imagined to paſs through every degree and minute of the meridian of a place, between the horizon and the zenith of that place: theſe are deſcribed by the diviſions on the quadrant of altitude in its motion about the body of the globe, when it is ſcrewed in the zenith of any place.

13. Parallels of Latitude, are ſmall circles parallel to the Ecliptic, imagined to paſs through every degree and minute of the colures between the ecliptic and the poles thereof. Theſe are

are represented by the divisions of the quadrant of altitude in its motion round the body of the globe, when it is screwed over the poles of the ecliptic.

Having described the imaginary circles of the Cœlestial Globe, we proceed now to the description of the stars, those glorious diamonds, sparkling in the immense expansion of the firmament, encircling the terrestrial orb at unmeasurable distance, which for multitude seems innumerable, yet the greatest and more visible may be numbered and named: and for this purpose, Astronomers (for order and method sake) have reduced many stars into one Image or Constellation, the better to know where to seek them; and being found, how to express them.

14. The number of constellations now drawn on the body of the Cœlestial Globe, are 66, and are as followeth.

The northern constellations 23, *viz.*

	Stars		Stars
1. Ursa Minor —	9	12. Auriga —	24
2. Ursa Major —	33	13. Sepentarius —	23
3. Draco —	—36	14. Serpens — —	14
4. Cepheus —	11	15. Sagitta — —	5
5. Bootes —	22	16. Aquila — —	9
6. Corona Borealis —	8	17. Antionius — —	7
7. Hercules — —	30	18. Delphinus —	—10
8. Lyra — —	10	19. Equiniculus — —	5
9. Olor, aut Cygnus —	17	20. Pegasus — —	23
10. Cossiopea —	23	21. Andromeda —	23
11. Perseus and Caput Medusa	27	22. Triangulum —	3
		23. Coma Berenices —	11
		In all	383

The zodiacal Constellations are 12, *viz.*

1. Aries — —	16	7. Libra — —	10
2. Taurus —	—32	8. Scorpio — —	26
3. Gemini —	24	9. Sagittarius —	—29
4. Cancer —	—16	10. Capricornus —	21
5. Leo —	—33	11. Aquarius — —	34
6. Virgo —	—39	12. Pisces — —	34
		In all	314

The

The southern constellations are 30, *viz.*

1. Cetus — —	26	17. Columbus —	10
2. Orion — —	39	18. Pisces Austrinus —	11
3. Flumen Eridanus —	43	19. Grus — —	13
4. Lepus — —	13	20. Phœnix — —	12
5. Canis Major —	13	21. Indus — —	12
6. Canis Minor or Canicula	2	22. Pavo — —	16
7. Argo Navis —	42	23. Avis Indica Touchan —	7
8. Robur Carolinum —	11	24. Apis Musca —	3
9. Hydra — —	27	25. Chameleon —	10
10. Crater — —	8	26. Triangulum Australis —	5
11. Corvus — —	7	27. Pisces Volans —	7
12. Centaurus —	30	28. Derado — —	7
13. Lupus — —	22	29. ApousAnserAmericanus	10
14. Crosero or the Crosiers -	5	30. Hydrus Serpens Austrina	10
15. Ara, or the Altar —	8		
16. Corona Austrina —	10	In all	439

There is added by Sir Charles Scarborough, a constellation called Cor Caroli, being one star in a crowned heart, laying between Ursa Major and Coma Berenices: so that the constellation now pourtrayed on the globe are 66 containing 1136 stars, besides many that are unformed, making in all more than 1300 stars, which are distinguished into six Degrees of Magnitude, or bignes: the biggest and brightest are called Stars of the First Magnitude; those next inferior in bignes and brightness are Stars of the Second Magnitude, &c. Stars of the Sixth Magnitude. These several magnitudes are expressed on the globe in several shapes, as may be seen in a little table placed on the globe, intitled Stellarum Magnitudines.

Section IV. *The use of the* Cœlestial Globe.

BEfore working any problem on this globe, I hold it necessary to explain several words of art used in Astronomy, and Geography, and are in these following Difinitions:

1. Altitude, is an arch of an azimuth circle, contained between the horizon and any parallel of altitude. Its counted on the brass quadrant of altitude, which represents any azimuth circle on the globe.

2. Ascension, is the rising of the sun or star, on any part of the Equinoctial above the horizon; and Descension, is the setting thereof.

3. Right Ascension, is an arch of the equinoctial intercepted between the beginning of Aries, and any meridian, and counted

counted according to the order and succession of the signs; or, 'tis that degree and minute of the equinoctial (counted as before) which cometh to the meridian with the sun, star, or with any point of the Heavens.

4. Oblique Ascension, is that degree and minute of the equinoctial (counted as before) which riseth with the center of the sun, or star, or with any point of the heavens: and Oblique Descension is the setting thereof.

5. Ascensional Difference, is the difference between the Right and Oblique Ascension, or descension: or it is the space of time the sun riseth, or setteth, before or after 6 of the clock.

6. Amplitude, is an arch of the horizon comprehended between the true east and west points of it, and the center of the sun or star; at their rising or setting.

7. Azimuth, is an arch of the horizon contained between the meridian of the place and any other azimuth circle. Or contained between the Prime Vertical, and any other azimuth circle.

8. Declination, is an arch of a meridian, comprehended between the equinoctial and the center of the sun, or star, or any point of the heavens: its north declination on the north side of the equinoctial, but south declination when on the south side thereof. And is counted on the brass meridian on the globe, and on the equinoctial colure.

9. Hour of the Day or Night, is an arch of the equinoctial, contained between the meridian of the place, and another meridian passing through the center of the sun at any time. This is counted on the brass hour circle, which is divided into the 24 hours of the day, and night; and hath a little brass index pointing to them as the globe is turned about: or it is counted on the equinoctial reckoning, 15d. an hour.

10. Latitude of a Star, is an arch of a circle of longitude contained between the ecliptic and the star's center: this is counted on the brass quadrant of altitude when screwed over the pole of the ecliptic, for then it represents a circle on longitude.

11. Latitude of a place, or Latitude upon the Earth, is an arch of the meridian of that place contained between the equator and that place: equal to which is the height of the pole (of the world) above the horizon. This is counted on the brass meridian of the globe: or it may be counted on the graduated meridian on the body of the globe.

So that Latitude in the Heavens, and Latitude on the Earth, are different things; one being an arch of a circle of longitude and applicable to the planets (except the sun, who hath no latitude) and stars: the other an arch of the meridian, and applicable to the places on the Earth.

12. Lon-

12. Longitude in the Heavens, is an arch of the ecliptic, comprehended between the beginning of Aries, and that circle of longitude which passeth through the center of the sun, star, or any point of the heaven, and counted according to the succession of the signs.

13. The Place of the Sun, or a star, with respect to the ecliptic, is the sine, and degree, and minute of that sign the sun or star is in.

14. Longitude of the Sun, or of a Star from the nearest Equinoctial Point, is how many degrees and minutes the sun or star is from the beginning of Aries, or Libra; either before or after them; which can never be more than 180 degrees.

15. Longitude on the Earth, is an arch of the equator, comprehended between the meridian of any place, and that meridian where longitude takes its beginning.

So that Longitude in the Heavens, and Longitude on the Earth, are vastly different, one being an arch of the ecliptic, the other an arch of the equator.

16. Meridian of a Place, is that meridian which passeth over the zenith of that place; to which when the sun cometh, its either noon or midnight: at the first, he is at his highest altitude above the horizon, and at the last, he is at his lowest depression for that day.

In like manner, any star coming to the meridian of any place, it is at the highest altitude, or lowest depression.

These things being well considered, the following Problems will be the better understood.

Problem 9. *The day of the month given; to find the sun's place in the ecliptic.*

The rule, 1. Seek the day of the month (in either account according to the Julian or Gregorian) as you find them placed in the kalendar on the upper side of the horizon.

2. Right against it, in the innermost circle, is the sine, degree, and minute, the sun shall be in that day at noon.

Example. *The 8th day of January in the Julian, or 19th of Gregorian Account; I demand the sun's place in the ecliptic?*

Right against the 8th of January in the Julian Kalendar, in the circle next within it, it is 29 degrees of Capricorn, in which sign and degree the sun will be the 8th of January.

In like manner, his place for February the 15th, is 7d. 30m. in Pisces.

Problem 10. *How to rectify the globe for any latitude, and to make it fit for use, at any given time.*

The

The rule, 1. The Globe being placed in the frame, by putting the brass meridian into the two notches that are in the north and south parts of the horizon, so that the graduated side thereof be towards the east, and it rests in the notch that is in the bottom of the frame: move the said meridian higher, or lower, till the given latitude in it doth just touch the upper part of the horizon on the north side thereof, if north latitude, but the south side, when south latitude.

2. Place the Brass Hour Circle about the pole, so that the hours of 12 and 12 lie directly over the graduated side of the brass meridian; and put the little index on the axis, so that it may move about as you turn the globe; then doth the upper 12 on the Hour Circle represent 12 at noon, and the lower 12 at midnight; and all the other figures correspond with the hours of the day and night.

3. By Problem 9. find the sun's place according to the given time; then seek the sun's place in the ecliptic on the body of the globe, and bring that degree to the brass meridian; there stay the globe, and then turn the little index, till it points just at the upper 12 in the hour circle.

Thus is the globe rectified to the given latitude, and the hour circle and index to the given time.

Example. *At London the 14th of February; I would have the globe rectified fit for use?*

1. Move the brass meridian till 51d. 32m. in it toucheth the north part of the horizon.

2. By Problem 9. the sun's place is 6d. 30m. in Pisces; which being found in the ecliptic on the globe, bring it to the brass meridian, and there staying the globe turn the little index to the upper 12 in the hour circle; and there set it so, that it may move with the globe, and it's done.

Problem 11. *The day of the month given; to find the sun's declination.*

The rule, 1. By Prob. 9. find the sun's place in the ecliptic.

2. Bring the sun's place (in the ecliptic on the globe) to the brass meridian, on which and right over the sun's place is his declination required.

Example. *The 14th of February; I desire to know the sun's declination?*

1. The sun's place in the ecliptic, for the 14th of February (found by prob. 9.) is 6d. 30m. in ♓.

2. Bring 6d. 30m. in ♓ (in the ecliptic on the globe) to the brass meridian, and then right over it on the brass meridian is 9d. 10m. which is the sun's declination, south decreasing. Or thus;

1. With

1. With a pair of compasses take the nearest distance from the sun's place in the ecliptic, 6d. 30m. in ♓. to the equinoctial on the globe.

2. Measure that distance on the equinoctial-colure, and it sheweth the declination 9d. 10m. as before.

Problem 12. *The day of the month given: to find the sun's right ascension.*

The rule, 1. As before, find the sun's place in the ecliptic, by Problem 9.

2. Bring the sun's place (as directed in Problem 11.) to the brass meridian, look what degree of the Equinoctial is cut by it, and that is the sun's Right Ascension required.

Example. *The 14th of February; I demand the sun's right ascension?*

1. The 14th of February his place in the ecliptic is 6d. 30m. in A, by Problem 9.

2. His place 6d. 30m. of ♓. being brought to the brass meridian, it cuts the equinoctial in 338d. 15m. the sun's right ascension.

Problem 13. *The latitude of a place, and the day of the month given; to find the time of the sun's rising, setting, and his amplitude.*

The rule, 1. Rectify the Globe (by Problem 10, fit for use) according to the given latitude, and given time.

2. Bring the sun's place (in the ecliptic on the globe) down to the horizon on the east-side thereof, and then the little index will point to the sun's rising in the hour circle; and the body of the globe stayed there, look what degrees of the horizon (counted from the east point thereof) standeth right against his place (in the ecliptic on the globe) that is the sun's amplitude at his rising.

In like manner turn the globe till you bring the sun's place to lie even with the west-side of the horizon, staying the body of the globe there, then will the index point to his setting, and against his place on the globe standeth his amplitude (on the horizon) counted from the west point thereof.

Example. *The 14th of February, at London, I demand the time of the sun's rising and setting, and his amplitude?*

1. The globe being rectified to the latitude of 51d. 32m. and the hour index to 6d. 30m. of ♓. then 'tis rectified to the given latitude and given time.

2. Bring 6d. 30m. of A, to the east-side of the horizon and staying the globe there, the index points to 6 hours ¾; that is ¾ after

after 6 is the sun's rising: and against 6d. 30m. of ♓, is 14d. 35m. on the horizon (from the east towards the south) which is the sun's amplitude at rising.

In like manner turn the globe till you bring 6d. 30m. of ♓, to the W. side of the horizon, and the index points to ¼ after 5, which is the sun's setting; and in the horizon you have his amplitude (the same as before) 14d. 35m. (from the west towards the south) which is the sun's amplitude at setting.

Problem 14. *The latitude of a place, and the day of the month given; to find the sun's oblique ascension, and descension.*

The rule, 1. Rectify the globe to the given latitude, and find the sun's place in the ecliptic for the given time.

2. Bring the sun's place in the ecliptic on the globe, to the east-side of the horizon, and then see what degree of the equinoctial is cut by the horizon, and that is the sun's oblique ascension.

3. In like manner bring the sun's place in the ecliptic to the west-side of the horizon, and it sheweth his oblique descension.

Example. *The 14th of February at London: I demand the sun's oblique ascension and descension?*

1. Rectify the globe to the given latitude 51d. 32m. according to Problem 10.

2. Bring 6d. 30m. of ♓ (the sun's place for the 14th of February) to the east-side of the horizon, and then it cuts the equinoctial in 326d. 50m. which is the sun's oblique ascension.

3. Bring 6d. 30m. of ♓ to the west-side of the horizon, it cuts the equinoctial in 326d. 30m. which is the sun's oblique descension.

Problem 15. *The latitude of a place, and day of the month given; to find the sun's altitude, and azimuth at any time of the day.*

The rule, 1. Rectify the globe and hour index, as before in Problem 10.

2. Screw the quadrant of altitude in the zenith; which I call rectifying the quadrant of altitude to the latitude of the place.

3. Turn the globe till the index point to the given hour of the day, and there stay the globe.

4. Move the quadrant of altitude till the graduated edge of it lie just on the sun's place in the ecliptic on the globe, and there stay it.

5. Look what degree on the quadrant of altitude is against the sun's place, and that is the sun's altitude.

6. Look what degree of the horizon is cut by the graduated edge of the quadrant of altitude, counted from the north, or from the south, that is the sun's azimuth.

Example.

Example. *At London the 17th of June, at 6 of the clock in the forenoon; I demand the ſun's altitude and azimuth?*

1. The globe being rectified by Prob. 10. turn it about till the hour index point to 6 in the morning, and there ſtay the body of the globe.

2. Screw the quadrant of altitude on 51d. 32m. (on the braſs meridian) which is the zenith, or London's diſtance from the equinoctial.

Note, In ſcrewing the quadrant of altitude on the braſs meridian, you muſt put the ſcrew-ſide of the notch, on the backſide thereof, and put it cloſe down, ſo cloſe to it, that the thin plate may be as near the body of the globe as poſſibly you can; yet ſo, as not to obſtruct its moving.

Alſo mind that you ſet the ſloped edge of the notch to the latitude of the given place.

3. Bring the graduated edge of the Quadrant of Altitude to 6d. 10m. of ♋, the ſun's place (for June the 17th) in the Ecliptic, and then on the Quadrant of Altitude (againſt it) is the 18d. 30m. his altitude at 6 of the clock.

4. And the Quadrant of altitude cuts the Horizon, in 104d. 50m. from the ſouth-eaſtward, which is the ſun's azimuth at the ſame time.

Problem 16. *The latitude of a place, the day of the month, and ſun's altitude given; to find his azimuth and hour of the day.*

The rule, 1. Rectify the Globe, Hour-Index and Quadrant of Altitude, as before.

2. Turn the body of the globe, and move the quadrant of altitude, till you bring the ſun's place in the ecliptic to lie juſt under his altitude on the quadrant; there ſtay them both.

3. Then will the graduated edge of the Quadrant point out the azimuth in the horizon from the north, or ſouth; and the index ſheweth the hour of the day.

Example. *At Barbadoes the 14th of February, in the forenoon, the ſun's altitude being 30d. I demand his azimuth and hour of the day?*

1. The globe being rectified to the latitude of Barbadoes, 13d. 30m. alſo the hour-index to 6d. 30m. of ♓, the ſun's place for the 14th of February, and the quadrant of altitude ſcrewed in the zenith.

2. Then move the globe and quadrant of altitude, till you bring 30 degrees on the latter to lie juſt over 6d. 30m. of ♓ in the ecliptic, and there ſtay them both.

3. Then doth the Quadrant of Altitude lie right againſt 72d. in the horizon, from the ſouth towards the eaſt, the ſun's azimuth, which is almoſt ESE. ½ E.

4. And

4. And then the hour-index points to 8 hours ¾, that is 45m. after 8 of the clock in the morning.

Problem 17. *The latitude of a place, the day of the month and sun's azimuth given, to find his altitude, and hour of the day.*

The rule, 1, Rectifie the globe, hour-index, and quadrant of altitude as before.

2. Turn the quadrant of altitude, to the given azimuth in the horizon, and there stay it.

3. Then bring the sun's place in the ecliptic (keeping the quadrant of altitude fixed) to the graduated edge thereof, (which is also before set to his given azimuth); and stay the globe there.

4. And then doth the ecliptic cut the quadrant in the required altitude, and the index sheweth the hour of the day desired.

Example. *At Barbadoes the 14th of February, the sun's azimuth in the afternoon, being WSW.½W. or 73d. south-westerly: I demand his altitude and hour of the day?*

Answ. Observing the foresaid directions, and turning the globe and quadrant of altitude towards the west, you will find the sun's altitude to be 30d. and the hour of the day 15m. after 3 in the afternoon.

Problem 18. *The latitude of the place, the sun's altitude, and azimuth given; to find his place in the ecliptic, and hour of the day.*

The rule. 1. Rectifie the globe to the latitude, and screw the quadrant of altitude to the zenith.

2. Turn the graduated edge of the quadrant of altitude to the given azimuth in the horizon, and there stay it.

3. Turn the body of the globe, (without stirring the quadrant out of its place) till the ecliptic cut the quadrant in the given altitude; which will then cut the ecliptic in the sun's place required?

4. Then turn the sun's place to the brass meridian, and rectifie the hour-index to 12.

5. Turn back the sun's place to the graduated edge of the quadrant (it being in the same place; that is, at the given azimuth as before) and then the index will shew the hour of the day required?

Note, In turning the globe according to the third step in this rule, the given altitude in the quadrant will cut the Ecliptic into two several signs, and yet the hour of the day sought by the fourth step, will be the same; so that unless the month be given, the sun's place cannot be determined.

Example. *At London, in October, the sun's altitude being 20d. and his azimuth S. E. or 45d. south-easterly: I demand his place in the ecliptic, and the hour of the day?*

Answ. The sun's place is 23d. 30m. in ♎, and it's 7m. after 9 in the morning, the 5th of October at London: also the sun's altitude and azimuth being the same, his place may be 6d. 30m. in ♓, and the hour the same, the 14th of February.

Note; All these problems may be wrought, having the sun's declination given, instead of the day of the month, which may be seen in the next problem.

Problem 19. *The latitude of a place, the declination, and altitude of the sun given, to find his azimuth, and hour of the day.*

The rule. 1. Rectifie the globe to the given latitude, and the quadrant to the zenith as before.

2. Bring the equinoctial colure to the brass meridian, and then set the hour-index, to the upper 12: which is rectifying it when the declination is given.

3. Move both globe and quadrant of altitude, till the given altitude on the latter meet with the given declination in the equinoctial colure on the former, and there stay them both.

4. Then doth the quadrant cut the horizon in the sun's azimuth, and the index sheweth the hour of the day required.

Also at the same time the brass meridian cuts the equinoctial in so many degrees (counting from the colure, allowing 15d. to an hour) as the required hour of the day is, either before or after noon.

Example. *At London, the sun's declination being 15d. north, and his altitude 19d. 30m. in the morning: I demand his azimuth, and hour of the day?*

Answ. The sun is east, and the hour 52m. after 6 of the clock, or 77d. of the equinoctial is intercepted between the colure and brass meridian: which makes 5h. 8m. from noon, at which time the sun is west in the afternoon.

In like manner may any of the preceding problems be wrought, observing these following General Directions.

1. Count the latitude on the brass meridian.
2. The declination on the colure from the equinoctial, either northward or southward; according to its name.
3. The altitude on the quadrant of altitude.
4. The azimuth in the horizon, from the brass meridian to the quadrant.
5. And the hour (from noon in degrees) on the equinoctial, from the equinoctial colure to the brass meridian.

Then having any three of these five given, the other two may be found, which I leave for the learner's exercise.

Note;

Note; All the foregoing problems, may be wrought on either globe; but the following only on the Cœlestial Globe.

Problem 20. *To find the declination, and right ascension of a star.*

The rule. Bring the given star to the brass meridian, and there stay the globe.

2. Then the center of the star cuts the brass meridian in its declination, counted from the equinoctial either northward, or southward.

3. And the brass meridian cuts the equinoctial in its right ascension, counted from the beginning of ♈ according to the succession of the signs.

Example. *I demand the right ascension, and declination of Aldebarn, or Oculus Tauri the bull's eye?*

Answ. According to the direction above you will find its right ascension 65d. 03m. and its declination near 15d. 55m. north.

Problem 21. *To find the latitude and longitude of a star.*

The rule. 1. Bring the solstitial colures to the brass meridian, that the pole of the ecliptic on the globe may be just under 23d. 30m. on the said meridian, and there fix the body of the globe.

2. Screw the quadrant of altitude just over the pole of the ecliptic.

3. Bring the graduated edge of the quadrant to the center of the star, and there stay it.

4. Then the star cuts the quadrant in its latitude, and the quadrant cuts the ecliptic in its longitude.

Example. I *demand the latitude and longitude of Arcturus, a star of the first magnitude in the constellation Bootes.*

Answ. This star's latitude is 30d. 57m. north, and its longitude 20d. 24m. in ♎, or 200d. 24m. from the beginning of ♈; and so for any other, as in the following table.

Stars names.	Magnit.	Longitude D. M.	Latitude D. M.	Right Ascen. D. M.	Declination D. M.
Pole-Star, or North-Star — — —	2	♊26.05	66.30 N	08.00	87.35 N
Last in Eridanus Acarnar — —	1	♓10.55	59.55 S	21.15	58.55 S
Whale's Jaw Cetus	2	♉10.29	12.37 S	42.00	02.59 N
Bull's Eye Aldebaran	1	♊ 5.17	5.30 S	65.03	15.55 N
Capella, or Auriga's left Shoulder — —	1	♊18.02	22.52 N	74.07	45.41 N
Orion's left foot Rege	1	♊13.00	31.10 S	75.21	08.33 S
Orion's right Shoulder	1	♊24.55	16.0[illegible] S	85.05	7.19 N
Great Dog, Sirius —	1	♋10.1[illegible]	[illegible] S	98.17	16.21 S
Lesser Dog, Procyon	1	♋22.00	15.5[illegible] S	111.14	05.54 N
Hydra's Heart, Alphard — —	1	♌23.28	22.21 S	138.31	7.29 S
Lyon's Heart, Regulus	1	♌26.01	00.37 N	148.26	13.17 N
Foot of the Crosier —	2	♍08.08	52.45 S	183.05	61.31 S
Virgin's Spike — —	1	♎20.01	02.02 S	197.44	09.43 S
Arcturus in Bootes —	1	♎20.24	30.57 N	210.48	20.39 N
Bright ✱ of the Harp Lyra — —	1	♑14.27	61.46 N	276.54	38.33 N
South Fish, Fomelhaut	1	♒29.59	21.05 S	340.35	31.03 S

Problem 22. *To find the rising, setting, and culminating of a star at any time, in any latitude.*

The rule, 1. Rectify the globe and hour-index, as in prob. 10.

2. Bring the star, (whose rising you would know) to the east part of the horizon, and then the index will point to the time of its rising: also the degree of the horizon against the star, is its amplitude at rising.

3. Bring the star to the brass meridian, and the index will shew the time of its culminating (or coming to the meridian) also the degree of the brass meridian, contained from the horizon to the star, is its meridian altitude.

4. Bring the star to the west part of the horizon, and then the index will shew the time of its setting: also against the star on the horizon, is its amplitude at setting, which is ever the same quantity as at rising.

This is so easy to perform, and so often done in the Problems concerning the sun, it needs no example.

Problem 23. *To know at any time what stars are above the horizon, either rising towards the meridian, or falling from it, towards their setting, also what's their altitude and azimuth.*

The

The rule. Rectify the globe, hour-index, and quadrant of altitude, as before in Problem 10.

2. Turn the globe 'till the hour index points to the given time of the day or night; and there stay the globe.

3. Then observe what stars are even with the east part of the horizon, those are then rising; and all those that are between the horizon and the east-side of the meridian, are risen above the horizon, and are rising towards the meridian.

4. All those stars near the brass meridian, are then near the meridian of that place; and those at the brass meridian, are then on the meridian of that place.

5. If the quadrant of altitude be put to any star, it will shew its altitude at that time and place, and in the horizon the quadrant shews its azimuth.

6. All those stars on the west-side of the meridian are falling from it towards their setting, those near the horizon are setting, and those below the horizon are set.

In a word, let the globe (by help of a Magnetical Needle, or Compass, or otherwise) be set so, as the north point of its horizon may point to the true north in the heavens, and the south point to the south; then imagine your eye placed within the globe at its center, and that the globe were transparent, or supposing a small round hole thro' the center of any star, now your sight passing through it, will direct to the star in the Heavens correspondent to that on the out-side of the globe.

This being mathematically well considered, will make the Use of the Globes easy, and very much conduce to the knowledge of the stars, a thing not a little necessary in Navigation, but too much neglected by most mariners.

Problem 24. *To know the hour of the night by the altitude of a known star.*

The rule. 1. Rectify the globe, hour-index, and quadrant of altitude, as before in Problem 10.

2. Turn the globe and quadrant of altitude till you bring the star against its given altitude in the quadrant, and there stay them.

3. Then will the index shew the hour required; and the quadrant will cut the horizon in the star's azimuth.

Note, If the star you observe be on the east-side of the meridian, then turn the quadrant of altitude on the east-side of the brass meridian of the globe: and if on the west-side, turn the quadrant also on the west-side.

Example. *At London, December the 12th the altitude of Regulus or the Lion's Heart, being 25d. 30m. oriental, or on the east-side of the meridian: I demand the hour of the night?*

Answ. According to the aforesaid rule, the hour is near 30m. after 10 at night, and the star's azimuth 78d. 30m. south-easterly, or east by south nearest.

So much for the use of the Globes, which is gone far beyond its first designed limit, occasioned by a constant resolution to be plain.

And by the way, let me advise those who have not conveniency for, nor ability to purchase Globes and yet would know the stars, they may attain it with a pair of hemispheres, wherein are all the constellations; and each star according to its longitude and latitude placed in them: such are made of near 20 inches diameter, to fold in a book, like a sea-chart, in 4 leaves; they are projected on the Plain of the Ecliptic, or as some say, on the Poles of the Ecliptic: so that in one hemisphere (which is one leaf) you have all the constellations on the north side of the ecliptic, and in another all the southern.

The Poles of the Ecliptic is the center of each hemisphere, and the margent going round them is the ecliptic, being divided into the 12 signs, and each sign into 30 degrees, each degree being subdivided into halves and quarters: and lines drawn from the center (or Pole of the Ecliptic) to the beginning of each sign.

On one of those lines is placed the degrees of latitude; and numbred from the ecliptic with 10, 20, &c. to 90, at the pole and center of it.

By these hemispheres any of the former Problems (wrought on the Cœlestial Globe) may be solved. As for instance;

To find the longitude and latitude of a star.

The rule, 1. Stretch out the silk-string (fastened in the Center for that purpose) over the Center of the given star, and it sheweth or cutteth the star's longitude in the Ecliptic.

2. With a pair of compasses take the distance from the center or the star to the center of the hemisphere; lay that distance on the scale of latitude from the center of the hemisphere, and it will shew the latitude required.

Example. *The foot of the Crosiers, a star of the second magnitude in the southern hemisphere, between Robur Carolinum, and Centaurus: I demand its latitude and longitude?*

1. Laying the like silk string over the star's center, it cuts the ecliptic in ♏ 8d. 8m. the star's longitude.

2. Take the star's distance from the center of the hemisphere, measure it on the solstitial colure, from the said center, and it reacheth to 52d. 45m. the star's latitude south.

There are drawn in these hemisphere's the equinoctial, tropics, polar circles, and poles of the world; all which are described by their names set to them; more circles may be drawn,

drawn, and are of use in solving other Problems; which shall be shewed after the Problems of Astronomy.

CHAPTER VII.

Spheric trigonometry, applied in Problems of Geography.

BEfore I treat of Great Circle Sailing, it's not amiss to discourse something in Geography; and for a more distinct knowledge thereof, take these following definitions and problems. These definitions are much the same as before, in Chapter 4. of Mercator's Sailing, in page 77.

Section 1. *Geographical definitions. Plate* 1. *fig.* 1.

THE Earth (on which we dwell) together with the Water, makes one round body or globe, which is the subject of Geography.

2. The Poles of the Earth, are two imaginary points, directly opposite upon the surface of it; that in the north, called the north pole; and that in the south, called the south pole: as P and I. Plate 5. fig. 1.

3. The Equator, or line under the equinoctial, is a line drawn round the globe, and lieth in the middle between both poles, cutting all meridians at right angles; is a great circle from which latitude taketh its beginning and in which longitude is reckoned, as Æ A Q. Plate 5. fig. 1.

4. Meridians are great circles drawn through both Poles, cutting the equator at right angles, as P Q I, P A I and PMI; answerable to them, are the North and South Lines drawn in any chart.

5. Parallels of latitude, are lesser circles drawn parallel to the equator; through every degree and minute of the meridian between the equator and each pole as *a l t* and Z ✱ *l t*, and are represented in any chart, by the east and west lines therein.

6. Latitude, is an arch of a meridian, contained between any parallel, and the equator, from whence it is counted both ways to each pole, where it ends in 90 degrees, which is the greatest latitude.

7. North Latitude, is on that side the equator towards the North Pole, and South Latitude towards the South Pole.

8. Difference of latitude, is an arch of a meridian and the nearest distance between any two parallels, and sheweth how far any place is to the northward or southward of another place, and never exceedeth 180 degrees.

9. Longitude, is reckoned on the equator, round which increasing to the eastward, it's counted (by some) till it end (where it first began) in 360 degrees, which is the greatest longitude: or, accordingly to Mr. Wakely in his Mariner's Compass rectified, it's counted from the meridian of London, increasing on both sides of it, eastward and westward, till it terminates in 180 degrees, at the opposite meridian.

10. Longitude of a Place, is an arch of the Equator, contained between the meridian of that place, and the first meridian where longitude taketh its beginning, and counted (by the old way) to the eastward of the first meridian, but (by the new way) its counted both eastward and westward, from the meridian of London: which in this account is the meridian, whence longitude taketh its beginning.

11. Difference of Longitude, is an arch of the equator, contained between the meridians of any two places, and never exceedeth 180 degrees.

12. The Distance of any two places, is an arch of a Great Circle, passing through them; and never exceedeth 180 Degrees.

13. The angle of position, or the angle of situation of places is an angle the arch of a great circle passing over two places makes with the meridian of one of them, and is not the course leading from one to the other.

In finding the Distance of Places, there are three Cases: as (1.) when they differ only in Latitude; (2.) when they differ only in Longitude; and (3) when the two places differ both in Latitude and Longitude; all which are performed by the following Problems.

Section II. *Geographic problems.*

Case 1. *Two places differing only in Latitude given; to find their distance.*

Note 1. TWo Places under one meridian or bearing north and south from each other, or in one longitude, are said to differ only in latitude.

2. Two places differing only in latitude, the difference of latitude is the distance required: in which there are two varieties.

Variety 1. Problem 1. *Two places both on the same side of the equator, that is, both in north, or both in south latitude; to find their distance.*

The rule. Subtract the lesser latitude from the greater, the remainder (reduce into leagues or miles) is the distance required.

Variety 2. Prob. 2. *If one place be on one side of the equator, the other on the other side; that is, one in north latitude, and the other in south latitude; to find their distance.*

The

The rule. Add the two given latitudes together, the sum (reduce into leagues or miles) is the distance required.

These are so easy, it's needless to give examples; being the same you had in chapter 3. section 3. general rule 2. in plain sailing, in page 55.

Case 2. *Two places differing only in longitude given; to find their distance.*

Note, Two places differing only in longitude lie east and west from each other, and are either in the equator or else in one parallel of latitude.

In this case are two varieties.

Case 2. Variety 1. Problem 3. *Two places in the equator, their longitudes being given; to find their distance.*

The rule. 1. According to the old way of counting the longitude, subtract the lesser longitude from the greater, the remainder (if less than 180 degrees) is the distance required; but when it's more, subtract it from 360 degrees, and this last remainder is the distance.

2. According to the new way of counting the Longitude in the Mariner's Compass Rectified, the rule is thus;

If both long. be east, or both west, subtract the lesser from the greater, the remainder is their distance: but when one is in east and the other in west long. add them, and the sum (if it exceed not 180d.) is the dist. and when it doth exceed 180 degrees, subtract it from 360 degrees, the remainder is the distance required, which is the same as in chap. 4. section. 2. problem 3. page 84. of Mercator's Sailing.

Case 2. Variety 2. Problem 4. *Two places in one parallel, or both in one latitude, their longitude being given to find their distance.*

Example. *I demand the distance between the Lizard and the Pengwin Island in Newfoundland?*

		d. m.		d. m.
Lizard / Pengwin Island	latitude	50 00 N.	longit.	5 24 w. / 53 10 w.
Subtract from		90 00	diff. lon.	47 46
Rem. is comp. lat.		40 00		

These places supposed both in the latitude of 50d. 00m. north, whose complement is 40d. 00m.

To delineate this problem Stereographically on the Plain of the meridian of the Lizard. Plate 5. fig. 1.

1. Describe the circle ÆPQI, with a chord of 60 deg. or half-tangent of 90 degrees, and quarter it, with the two diameters or right circles PAI and ÆAQ. Then is P the north pole, I the south pole, and ÆAQ the equator.

2. By

2. By problem 2. case 2. page 104. of Spheric Geometry make the angle ÆPN equal to 47d. 46m. (the difference of Longitude) by drawing the oblique circle P⊙NI, with the secant thereof.

3. Make PZ equal to 40d. 00m. (the complement of the given latitude) by prob. 6. case 1. page 109. of Spheric Geometry.

4. Through Z draw the parallel circle Z⊙ I t (by problem 9. case 2. in page 111. of Spheric Geometry,) with the tangent of 40d. 00m. (the complement of the given latitude) to cut the oblique circle P⊙NI in ⊙: then Z represents the Lizard, and ⊙ Pengwin Island, both in one parallel of latitude.

5. Then through Z and ⊙, draw a great circle, as is the oblique circle Z⊙C, and it's done, for Z⊙ on the oblique circle is the distance required, which is measured by problem 7. case 3. in page 109. of Spheric Geometry.

To find their distance by Trigonometry, 'tis to be noted;

That in the oblique spheric triangle ZP⊙. Plate 5. fig. 1.

1. The side ZP equal to P⊙ is the comp. of the lat. 40d. 00m.

2. The angle ZP⊙ the difference of longitude——47d. 46m.

3. The side Z⊙ the distance of the two places; which to find, let fall the perpendicular PB (by drawing an oblique circle with the secant of 23d. 53m. half the (given) difference of longitude to cut the oblique circle Z⊙ in B) and it divides the oblique spheric triangle into two equal rectangle spheric triangles PBZ and PB⊙, in each the hypotenuse, and one angle is given.

1. The angle ZPB equal to BP⊙, is half the difference longitude, 23d. 53m.

2. The leg ZB equal to B⊙, is half the difference required.

Therefore the proportion by chapter 5. section 4. problem 2. case 4. page 126. of Rectangular Spheric Trigonometry, is thus:

As radius, is to the sine complement of the latitude; so is the sine of half the difference of longitude, to the sine of half their distance required. But in short thus,

As radius ·· S. hypot. PZ :: S. angle ZPB ·· S. leg. ZB ½ the dist.
As S. 90d. ·· S. 40d. 00m. :: S. 23d. 53m. ·· 15d. 05m.
Which being doubled makes the distance 30d. 10m. or 1810 minutes, which is the distance between the Lizard and Pengwin Island, in the arch of a great circle.

Problem 5. *To find how many miles or minutes of the equator make a degree of longitude in any parallel of latitude.*

The rule or proportion is;

As radius, is to 60 miles or minutes a degree of the equator.
So is the sine complement of the latitude, to the miles or minutes of the equator, which makes a degree of longitude in the parallel required.

Example.

Example. *How many miles will make a degree in the latitude of London.*

As radius ∙∙ S.c. lat. :: a deg. in the equa. ∙∙ a deg. in the par.
As S. 90d. ∙∙ S. 38d. 28m. :: 60 minutes ∙∙ min. 37. 32. parts.

The miles of the æquator that make a degree of longitude in the latitude of 51d. 32m.

Case 3. *Two places differing both in latitude and longitude, their latitudes and longitudes being given; to find their distance.*

Note, In this case are three varieties.

Variety 1. Problem 6. *One place in the equator, and the other towards either of the poles.*

Example. *Suppose the Lizard and the entrance of the river Amazons, their latitudes and longitudes being as followeth: I demand their distance?*

		d. m.		d. m.
Lizard	lat.	50d. 00	longit.	5. 24 W.
Amaz. river				48. 04 W.
Difference of longitude	— — — —			42. 40

To delineate it Stereographically on the plain of the meridian of the Lizard. Plate 5. fig. 1.

1. The circle being described, and quartered as before, in problem 4. make ÆZ. on the primitive circle equal to 50d. 00m. the latitude of the Lizard, by problem 6. case 1. in page 109. of Spheric Geometry.

2. By the same problem, case 2. lay 42d. 40m. the given difference of longitude, on the right circle ÆAQ (which is the æquator) that is, take the half-tangent 42d. 40m. the contrary way, and lay it from ÆN.

3. Then through Z and N draw a great circle, as is the oblique circle ZNC, and it's done: for ZN measured by problem 7. case 3. in page 109. of Spheric Geometry) is the distance required.

But to find their distance by trigonometry. Observe,

That in the rectangle spheric triangle ZÆN. Plate 5. figure 1.

1. The leg ZÆ is the latitude of the Lizard, 50d. 00m.

2. The leg ÆN the difference of longitude between them 42d. 40m.

3. Hypotenuse ZN their distance required, to find which by (chapter 5. section 4. problem 5. case 14. in page 140. of Rectangular Spheric Trigonometry) the proportion is thus:

As radius is to the sine complement of the Lizard latitude.

So is the sine complement of their difference of longitude; to the sine complement of their distance required. But in short thus.

Radius

Radius ·· S. c. leg ZÆ :: S. c. leg ÆN ·· S. c. hypot. ZN the dist. S. 90d. ·· S. 40d. 00m. :: S. 47d. 20m. ·· S. 28d. 12m. whose complement is 61d. 48m. equal to 3708 minutes is the distance between the Lizard and river Amazons.

Case 3. Variety 2. Problem 7. *Two places lying towards one of the poles; that is both in north latitude, or both in south latitude, their latitudes and longitudes being given, to find their distance.*

Example. *I demand the distance between the Lizard and island Barbadoes.*

		d. m.		d. m.
Lizard	lat.	50 00	longit.	5 24 W.
I. Barbadoes,		13 00		57 54 W.
Difference of longitude — — —				52 30

To delineate this Stereographically, on the plain of the meridian of the Lizard.

1. Having described the primitive circle, and quartered it as before, make the angle ÆPM by problem 2 case 2. in page 104. of Spheric Geometry, equal to 52d. 30m. the given difference of longitude, by drawing the oblique circle, PMI with the secant thereof.

2. On the primitive circle (by prob. 6. case 2. in page 108 of Spheric Geometry) make PZ equal to 40d. 00m. the complement of the Lizard latitude, by having the chord thereof from P to Z.

3. Draw the parallel circle a L l t (by problem 9. case 2. in page 111. of Spheric Geometry) at 13d. 00m. (Barbadoes latitude) distance from the right circle ÆAQ, the æquator to cut the oblique circle PMI in L.

4. Then thro' Z and L draw a great circle, as the oblique circle ZLNC, and it's done: for ZL (measured by problem 7. case 3. in page 109. of Spheric Geometry) is the distance required.

But by spheric trigonometry, to find their distance, it is to be noted.

That in the Oblique Spheric Triangle, ZPL. Plate 5. fig. 1.

1. The side PZ is the comp. of the Lizard, lat. 40d. 00m.

2. The side PL the comp. of Barbadoes lat. 77d. 00m.

3. The angle ZPL their difference of longit. 52d. 30m.

4. The side ZL their distance required.

To find which, (by chapter 5. section 5. problem 9. case 8. in page 133. of Spheric Trigonometry Oblique) the rule is,

First, As radius is to the sine complement of the difference of longitude; so is the tangent complement of the greater latitude, to the tangent of a fourth arch. Which

Which being subtracted from the complement of the lesser latitude, when the difference of longitude is less than 90 degrees, but when more than 90 degrees from its supplement to 180 degrees, the remainder is the Residual Arch. Then,

Secondly, As the sine complement of the Fourth Arch aforesaid, is to the sine complement of the Residual Arch; so is the sine of the greater latitude, to the sine complement of the distance required. But, in short, as follows;

As radius ·· S. c. angle ZPL. :: T. side ZP ·· T. 4th arch.
As S. 90d. ·· S. 37d. 30m. :: T. 40d. 00m. ·· T. 27d. 04m. which being subtracted from the side PL 77d. 00m. the Remainder is the residual arch — — 49d. 50m.

Then again say,

As S. c. 4th arch ·· S. c. resid. arch :: S. c. side ZP ·· Sc. side ZL.
As S. 62d. 56m. ·· S. 40d. 04m. :: S. 50d. 00m. ·· S. 33d. 37m.

Whose complement 57d. 23m. or 3383 minutes, which is the distance from the Lizard to island Barbadoes in the arch of a great circle.

Case 3. Variety 3. Problem 8. *Two places, one in the north latitude, the other in the south latitude; their latitudes and longitudes given to find their distance.*

Example. *I demand the distance from Cape Cod in New England, to Cape Bona Esperance or Cape of Good Hope in Africa.*

		d. m.		d. m.
Cape Cod.	lat.	42 10 N.	longit.	67 45 W.
C. Bon. Esp.		34 25 S.		17 10 E.

Sum of longitude is — — — — 84 55

To delineate it Stereographically on the plain of the meridian of Cape Cod, plate 5. figure 1.

1. The primitive circle being described, and quartered as before directed, make (by problem 2. case 2. in page 104 of Spheric Geometry) the angle ÆPM equal to 84d. 55m. the given sum of longitudes, by drawing the oblique circle PMI with the secant thereof: but the secant is so large, that it's not easy to do, therefore in such cases, lay it on the right circle ÆMAQ, the æquator (by problem 6. case 2. in page 109. of Spheric Geometry) from Æ, to M that is from the scale of half tangents the contrary way; and laying a bow screwed up to the three points PM, and I, draw the oblique circle by it.

2. On the primitive circle (by problem 6. case 1. in page 109.) make PZ equal to 47d. 50m. the complement of Cape Cod's latitude.

3. Draw the parallel circle a D l t (by problem 9. case 2. in page 111.) at 34d. 25m. Cape Bon Esperance lat. (or distance from

from the right circle ÆAQ, the equator) to cut the oblique circle PMI, in D, representing Cape Bon Esperance.

4. Through Z and D; draw a great circle, as the oblique circle ZDC, and it's done: for ZD measured by problem 7. case 3. in page 109. of Spheric Geometry) is the distance required.

By Spheric Trigonometry, to find their dist. it's to be considered, That in the oblique spheric triangle ZPD. Plate 5. fig. 1.

1. The side PZ is the comp. of Cape Cod's lat. 47d. 50m.

2. The side PD the distance of Cape Bon Esperance, from the north pole, or its latitude added to 90d. that is 124d. 25m.

3. The angle DPZ their sum of longitudes 48d. 55m.

4. The side ZD their dist. required, which is thus found.

By chapter 5. section 5. problem 9. case 8. page 133 of Spheric Trigonometry Oblique, the proportions are these.

First, As radius is to the sine complement of their sum of longitudes, so is the tangent complement of one of the given latitudes, to the tangent of a fourth arch. Then,

If the sum of longitudes be less than 90d. subtract the fourth arch out of the other latitude, added to 90d. but if the sum long. be more than 90d. from the supplement thereof to 180d. the remainder is the residual arch. And then,

Secondly, As the sine complement of the fourth arch, is to the sine complement of the residual arch; so is the sine of the latitude first taken, to the sine complement of the distance required. But in short thus;

As radius -- S. c. ang. DPZ. :: T. side PZ : T. 4th arch.
As S. 90d. -- S. 05d. 05m. :: T. 47d. 50m. : T. 4d. 35m. which
being subtracted from the side PD — 124d. 25m.
The remainder is the residual arch — —119d. 50m.
Then say,
S. c. 4th arch. -- S. c. residual arch. :: S. c. side PZ -- S. c. side ZD.
S. 84d. 35m. -- S. 28d. 05m. :: S. 42d. 10m. -- S. 18d. 59m.
Which added to — — — — 90d. 00m.
The sum is the side ZD their distance 108d. 59m.

Or 6599 minutes is the distance from Cape Cod to Cape Bona Esperance, in the arch of a great circle.

CHAP. VIII.

Of the third part of Navigation, or the doctrine of spheric trigonometry, applied in Great Circle Sailing.

GReat Circle Sailing, as it's the exactest, so it's the most difficult, and hardly possible for a ship exactly to sail by; yet

yet it may be of good advantage to keep conveniently near it, especially in a parallel (or east and west) course.

2. Great Circle-Sailing, is sailing by, or upon the arch of a great circle, passing thro' the two places.

3. In Great Circle-Sailing, are but three cases, *viz.* (1.) when two places differ only in latitude; and (2.) when they differ only in longitude; and (3.) when they differ both in latitude and longitude.

Case 1. *Two places differing only in latitude, their latitudes given, to find their distance.*

1. This is the same with chapter 7. section 2. Problem 1. and 2. in page 168 of Geography, to which I refer the reader for finding their distance, and so pass to

Case 2. *Two places differing only in longitude, the latitude and longitude being given; to find their distance in the arch of a great circle, and all that's requisite in Great Circle-Sailing.*

1. This is the same with chapter 7. section 2. problem 3. and 4. in pages 169 and 170. of Geography, to find their distance.

2. These places are either in the equator, or in one parallel, and lie east and west from each other; but their distance in that parallel, is not their nearest distance, the parallel being a lesser circle.

3. The distance in the parallel hath been shewed in chapter 4. section 3. problem 10. of Mercator's-Sailing, in page 93, and their distance in the arch of a great circle, is found by chapter 7. section 2. problem 4. in page 170. of Geography. But the angles of position made by the great circle and its latitude, and longitude at any assigned proportion, together with the course, and distance from place to place, so assigned in it, is the work now.

Case 2. Prob. 1. *Suppose the Lizard, and Pengwin-Island, both in the latitude of 50d. 00m. north, whose difference of longitude is 47d. 46m. as before in prob. 4. in page 170, of Geography,) I demand the angles of position? The great circles distance between them? The latitude of the arch at every five degrees difference of longitude? And the course, and distance of each of them according to Mercator.*

This problem is delineated by the directions in Problem 4. of Geography, in page 170. And observe that,

In the oblique spheric triangle APC. Plate 5. Fig. 2.

1. A represents the Lizard.
2. C Pengwin Island.

3. The

3. The side PA equal to PC, the complement of their latitude 40d.

4. The angle APC the difference of longitudes 47d. 46m.

5. The angle CAP equal to ACP the angle of position at each place.

6. The side AC, the greater circle's distance between them.

First, For the angle CAP, equal to ACP, the angle of position at the two places.

Draw the perpendicular PB, (as was taught in problem 4. of Geography, in page 170.) which divideth the oblique triangle APC into two equal rectangle spheric triangles ABP and CBP; in each the hypotenuse, and one angle is given. That is,

1. The hypotenuse PA, equal to PC, the complement of their latitude 40 degrees.

2. The angle BPA, equal to BPC, half their difference of longitude 23d. 53m.

3. The angle BAP, equal to BCP, the angle of position, at each place.

4. The leg AB, equal to BC, half the Great Circle's distance.

5. The leg BP, the complement of the arch's great lat.

And by chapter 5. section 4. problem 2. case 6. of Spheric Trigonometry Rectangular, in page 126. the proportion is thus:

As radius, is to the sine of the latitude; so is the tangent of half the difference of longitude, to the tangent complement of the angle of position at each place. That is;

As radius ·· S. c. hypot. AP :: T. angle APB ·· T. c. angle BAP.
As S. 90d. ·· S. 50d. 00m. :: T. 23d. 53m. ·· T. 18d. 44m.
Which being subtracted from — — — 93d. 00m.

Remainder is the angle of position at each place 74d. 16m.

Secondly, The leg AB, equal to BC, is found (by problem 4. of Geography, in page 170.) 15d. 05m. and therefore the side AC is 30d. 10m. or 1810 minutes, the distance of the two places in the arch of a great circle.

Thirdly, To find the latitude by which the arch shall pass at every 5 degrees difference of longitude from A representing the Lizard; these things following must be observed.

First, Find the leg BP, the complement of the greatest latitude by which the arch (of the great circle) doth pass; and that (by chapter 5. section 4. problem 2. case 5. of Spheric Trigonometry Rectangular, in page 126.) is thus;

As radius, is to the sine complement of half the difference of longitude.

So is the tangent complement of the given latitude, to the tangent complement of the arch's greatest latitude: in short thus;

As

As radius ∴ S. c. angle B P A :: T. hypot. P A ∴ T.c. leg. BP.
As S. 90d. ∴ S. 66d. 07m. :: T. 40d. 00m. : T. 37d. 30m.
Which being subtracted from ——— 90d. 00m.

Remainder is the arch's greatest latitude ——— 52d. 30m.

Secondly, To find the latitude by which the arch of the great circle passes at every 5 degrees of longitude from A, draw meridians from P, as Pd, Pe, Pf, *&c.* which may most easily be done Gnomonically, being then right lines, and that is thus;

The Gnomonic projection. Plate 5. *figure* 3.

1. Make the angle APC equal to 47d. 46m. the difference of longitude between the two given places.

2. Make PA, and PC, each equal to the tangent of 40d. 00m. the complement of the given latitude.

3. Draw the line AC, which represents the arch of a great circle between them.

4. Let fall the perpendicular PB, which being measured on the scale of tangents, is 37d. 30m. the complement of the arch's greatest latitude.

5. Then draw lines from P, each 5 degrees distance from A, as Pd, Pe, Pf, Pg, Ph, Pi, Pk, Pl, and Pm; which are meridians, and each 5 degrees of longitude from A, the Lizard.

6. Measure Pd, Pe, Pf, &c. on the scale of tangents, and it sheweth the complements of the latitudes of the arch, at the respective places d, e, f, &c.

These are found (by Spheric Trigonometry) after this manner. The several pricked lines Pd, Pe, &c. are so many hypotenuses, to as many rectangular spheric triangles, which have one common leg BP, the complement of the arch's greatest latitude.

Now in each of these rectangular spheric triangles, there is given a leg, and its adjacent angle, to find the hypotenuse; that is, in the triangle dBP, there is given the leg BP, and angle B Pd; to find the hypotenuse Pd, and so in all the rest.

And the several angles BPd, BPe, &c. are found by a continual subtraction of 5 degrees from the angle BPA 23d. 53m. half the difference of longitude, till the remainder be less than 5 degrees, which being taken out of 5 degrees, and to this last remainder add 5 degrees successively till the sum exceed not 23d. 53m. That is;

	d. m.		d. m.
From the angle BPA	23. 53	Then to the angle BPH	01. 07
Subtract the ang. APd	5. 00	Add the angle = hPi	05. 00
Remaind. is ang. BPd	18. 53	Sum is the angle BPi	06. 07
BPe	13. 53	BPk	11. 07
BPf	08. 53	BPl	16. 07
BPg	03. 53	BPm	21. 07
Which subtract from	05. 0	These angles are called Vertical Angles, or Angles at the Pole.	
Is the angle BPH =	01. 07		

Then find (by chapter 5. section 4. problem 3. case 9. of Spheric Trigonometry Rectangular, in pages 127, and 128.) the several latitudes of the arch, which is by this proportion.

As radius, is to the sine complement of the vertical angles;

So is the tangent of the arch's greatest latitude, to the tangent of the arch's latitude at the respective places. Or,

As radius ·· S. c. BPD, BPE, &c. :: T. c. leg BP ·· T. c. Pd, Pe, &c.

As S. 90d. ·· S. 71d. 07m. :: T. 52d. 30m. ·· T. 50d. 48m. lat. at d.

76 07	—	—	51.41	Latitude at	e
81 07	—	—	52.10		f
86 07	—	—	52.26		g
88 53	—	—	52.30		h
83 53	—	—	52.29		i
78 53	—	—	51.59		k
73 53	—	—	51.23		l
68 53	—	—	50.34		m

So that by the Gunter, the extent from the sine of 90 degrees, to the sine of 71d. 07m. will reach from the tangent of 52d. 30m. to tangent 50d. 58m. And the extent from sine 90d. to sine 76d. 07m. will reach from tangent 52d. 30m. to tangent 51d. 41m. Also from sine 90d. to sine 81d. 07m. reacheth from tangent 52d. 30m. to tangent 52d. 10m. and so on for the rest.

But by logarithms it may be thus contracted; because the first and third terms in each proportion are the same, and radius being the first, it follows,

That to the tangent of the arch's greatest latitude, add the sine complement of each vertical angle, and from their sum abate radius, the remainder is the tangent of the arch's latitude at each place required. As for example.

Arch

Arch greatest lat. 52d.30 tan. 10.115019 (d. m.)

Comp. vertical angle				d. m.	Latitude of the place at
71.07	sine	9.971974			
		10.090993	tang.	50.58	d
76.07	sine	9.987124			
		10.102143	tang.	51.41	e
81.07	sine	9.994759			
		10.109778	tang.	52.10	f
86.07	sine	9.999002			
		10.114021	tang.	52.26	g
88.53	sine	9.999917			
		10.114936	tang.	52.30	h
83.53	sine	9.997520			
		10.112539	tang.	52.29	i
78.53	sine	9.991774			
		10.106793	tang.	51.59	k
73.53	sine	9.982587			
		10.097606	tang.	51.23	l
68.53	sine	9.969811			
		10.084830	tang.	50.34	m

Thirdly, to find the course, and distance of the aforesaid places, having now the latitude, and longitude of them; this is done by chapter 4. section 3. problem 2. of Mercator's sailing, in page 86.

As for example. To find the course and distance from A to d.

There is given the latitude of A 50d. 00m. north, and of d 50d. 58m. north, with their difference of longitude 5d. or 300 minutes west.

There meridional difference of latitude (by the table of meridional parts, in pages 120, and 124.) is 91 minutes: therefore;

For the courses, the proportion is;

As merid. diff. lat. .. diff. long. :: radius .. T. of the course.
As 91 minutes .. 300 min. :: T. 45d. .. T. 73d. 07m. N. Westerly from A to d is the first course.

For the distances, the proportion is;

As S. c. course .. diff. lat. :: raidus .. distance.
As S. 16d. 53m. .. 58 min. :: S. 90d. .. 200 min. from A to d.

After the same manner find the courses and distances from d to e, from e to f, &c. as follows.

For the courses, the proportions are;

As 69 min. ·· 300 min. :: T. 45d. ·· T. 77.02 N W. from d. to e.
47 — — — 81.06 from e to f.
26 — — — 84.02 from f to g.
6 — — — 88.46 NW. from g to h.
14 — — — 87.15 SW. from h to i.
37 — — — 83.08 from i to k.
57 — — — 79.14 from k to l.
78 — — — 75.26 from l to m.
As 53 min. ·· 166 min. :: T. 45d. ·· T. 72d. 18m. SW. from m to C.

For the distances, the proportions are.

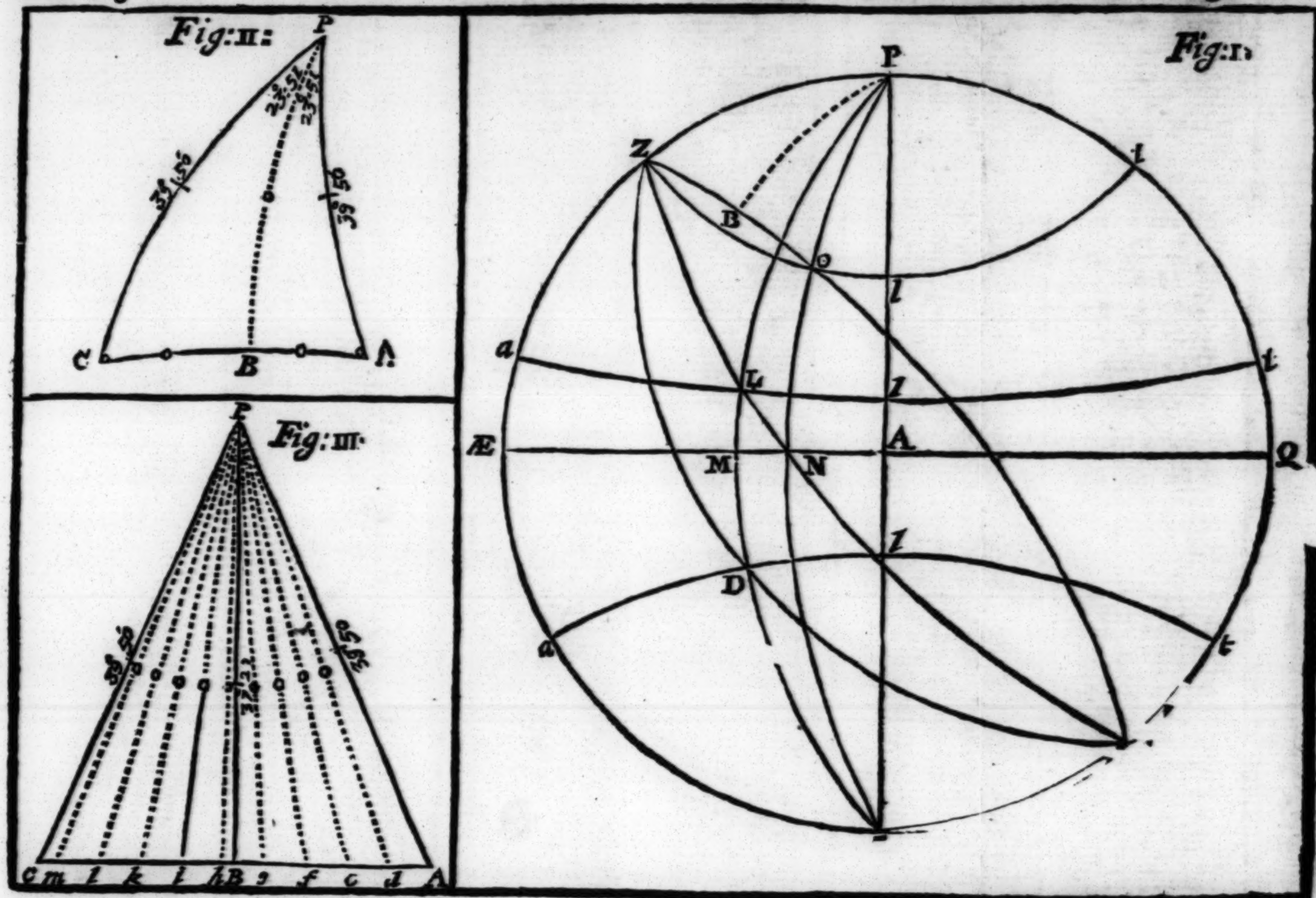
As S 12d. 58m. ·· 43 min. :: S. 90d. ·· 192 min. from d to e.
8d. 54m. ·· 29 — 187 — from e to f.
4d. 58m. ·· 16 — 185 — from f to g.
1d. 14m. ·· 04 — 186 — from g to h.
2d. 45m. ·· 09 — 187 — from h to i.
6d. 52m. ·· 22 — 187 — from i to k.
10d. 46m. ·· 36 — 190 — from k to l.
14d. 34m. ·· 49 — 194 — from l to m.
17d. 42m. ·· 34 — 111 — from m to C.

Which place orderly as in the table following.

Places.	*Places Latitudes.*	*Meridional Parts.*	*Mer. Diff. Lat.*	*Difference of Longitude.*	*Diff. of Latitude*	*Courses from Place to Place.*	*Distances of Places.*
	d. m.	Min.	Min.	d. m.	Min.	d. m.	Min.
A	50.00	3474		5 or 300	58	N 73.07 W	200
d	50.58	3566	92	5 or 300	43	N 77.02 W	192
e	51.41	3635	69	5 or 300	29	N 81.06 W	187
f	52.10	3682	47	5 or 300	16	N 85.02 W	185
g	52.26	3708	26	5 or 300	04	N 88.46 W	186
h	52.30	3714	6	5 or 300	09	S 87.15 W	187
i	52.21	3700	14	5 or 300	22	S 83.08 W	187
k	51.59	3633	37	5 or 300	36	S 79.14 W	190
l	51.23	3600	57	5 or 300	49	S 75.26 W	194
m	50.34	3528	78	2d46 or 166	34	S 72. 1 W	111
C	50.00	3475	53	The whole distance is			1819

But

Plate 5. Place this next after Page 180.



But in regard moſt of the courſes in the table are ſo near the weſt, you may ſail WNW. 927 min. until you are in the latitude of 56d. 00m. north; and then WSW. 927 min. farther, you will arrive at the port deſired.

By this means you alter the latitude 6d which is conſiderable, in reſpect of the benefit of obſervation; beſides the diſtance (this way) is but 56 minutes more than that of a great circle, and not above 24 minutes more than the parallel or weſt diſtance; which is evident, if you compare Chap. 4. ſection 3. problem 10. of Mercator's Sailing, in page 39, with this.

Caſe 3. *Two places differing both in latitude, and longitude; their latitudes, and longitudes being given; to find their diſtance in the arch of a great circle, and all that is required in Great Circle-Sailing.*

Note, When two places differ both in latitude and longitude, they lie neither in one parallel nor under one meridian, of which here are three kinds, *viz.* (1.) one place under the equator, and the other in north, or ſouth latitude. (2.) Both places in north, or both in ſouth latitude: and (3.) One place in north latitude, and the other place in ſouth latitude.

Theſe three kinds of places differing both in latitude and longitude; how to find their diſtance in the arch of a great circle, hath been ſhewed in chapter 7. ſection 2. caſe 3. problems 6, 7 and 8, of Geography, in pages 171, 172, 173, and 174. But to find the angles of poſition, and what elſe is requiſite in Great Circle-Sailing, is the work of the three following problems.

Caſe 3. The firſt kind, *One place under the equator; the other in north or ſouth latitude: as for example.*

Problem 2. *Suppoſe the Lizard and the entrance of the river Amazones; I demand the angles of poſition? the great circle's diſtance between them? The latitude of the arch at every 10 degrees difference of longitude? with the courſe and diſtance of each of them, according to Mercator?*

The latitude, and longitude of theſe places, ſuppoſed to be as follows:

		d. m.		d. m.
Lizard	latitude	50. 00	longitude	5. 24 W.
Amaz. river.		00. 00		48 04 W.
And their difference of longitude			—	42 40 W.

This problem is delineated by the directions in problem 6 of Geography in page 172. And here note; That,

In the Rectangle Spheric Triangle ZÆN. Plate 7. fig. 1.

1. Z represents the Lizard.
2. N the entrance of Amazon river.
3. ZÆ the latitude of the Lizard, 50d. 00m.
4. The leg ÆN their difference of longitude 42d. 40m.
5. ÆZN the angle of position at the Lizard.
6. ÆNZ the complement of the angle of position at Amazones, in the equator.
7. The hypotenuse ZN the great circle's distance between them.

For the angles ÆNZ, or ÆZN (by chapter 5. section 4. problem 5. case 13 and 14. of Spheric Trigonometry Rectangular, in pages 128 and 129, the proportions are these:

As radius is to the sine of the latitude; so is the tangent complement of the difference of longitude to the tangent complement of the angle of position at the place having latitude: that is,

As radius ⁚ S. leg ÆZ :: T. c. leg ÆN ⁚ T. c. angle ÆZN.
As S. 90d. ⁚ S. 50d. 00m. :: T. 47d. 20m. ⁚ T. 39d. 44m.
Which subtract from — —90d. 00m.

Rests the angle of position at the Lizard 50d. 16m.

And again,

As radius, is to the sine of the difference of longitude; so is the tangent complement of the Lizard latitude, to the tangent of the angle or position at the place in the equator; that is,
As radius ⁚ S. leg ÆN :: T. c. leg. ÆZ ⁚ T. c. angle ÆNZ.
As S. 90d. ⁚ 42d. 40m. :: T. 40d. 00m. ⁚ T. 29d. 38m. the angle of position at Amazons, which sub. from 90d. 00m.

Angle ÆNZ—50d. 22m.

For the hypotenuse Z N the great circle's distance between them, that's found by chapter 7. section 2. case 3. problem 6. of Geography, (in pages 170, and 171.) to be 61d. 48m. or 3708 minutes.

To find the latitude by which the arch shall pass, at every 10 degrees difference of longitude, from Z representing the Lizard, observe the following Stereographic projection on the plane of the equator. Plate 6. figure 1.

1. Describe the primitive circle, on the center P, which represents the pole of the world, through it draw the right circle PZÆ, representing the meridian of the Lizard, and from the half-tangents lay 40d. the complement of its latitude from P to Z.

2. On the primitive circle lay 42d. 40m. the difference of longitude from Æ to N; also lay 10 deg. from Æ to f, from f to g, and so on to i.

3. Thro'

3. Thro' Z representing the Lizard, and N the entrance of Amazones river, draw a great circle, as ZN.

4. Draw the right circles Pf, Pg, Ph, and Pi; which are meridians, and cut the arch ZN in a, b, c, and d; the respective places whose latitudes are required.

5. Measure af, bg, ch, and di, on the scale of half-tangents (the contrary way) and it sheweth the latitude of the arch at those places; and to find them,

By spheric trigonometry.

The several right circles af, bg, &c. are so many perpendiculars to as many several rectangle spheric triangles which have one common angle ÆNZ, the complement of the angle of position at that place, which is in the equator.

Now in each of these rectangle spheric triangles, there is given a leg, and it's adjacent angle, to find the other leg, which is the leg opposite to the given angle; that is, in the triangle afN, there is given the leg fN, and angle aNf; to find the leg af, and so in all the rest of the triangles.

And the several legs Nf, Ng, &c. are found by a continual subtraction of 10 degrees from the difference of longitude, till the remainder be less than 10 degrees. The remainders I call vertical arches, and is thus found.

		d. m.
From the leg —	ÆN	42 40
Subtract the arch —	Æ f	10 00
Remaind. is the leg	N f	32 40
	N g	22. 40
	N h	12. 40
	N i	2. 40

Then (by chapter 5. section 4. problem 3. case 7. of Spheric Trigonometry Rectangular, in pages 127 and 128.) to find the several latitudes of the arch, the proportion is thus,

As radius, to the sine of the vertical arch;

So is the tangent complement of the angle of position (at the place in the equator,) to the tangent of the arch's latitude. Or thus;

As radius ·· S. Nf. Ng, &c. :: T. angle aNf ·· T. leg af, bg, &c.

As S. 90d. ··	S. 32d. 40m. ::	T. 60d. 22m. ··	T. 43 30	Latit. of	a
	22 40	— — —	34 07		b
	12 40	— —	21 05		c
	2 40	— —	4 41		d

I have calculated the latitude of the arch for every 10 degrees difference of longitude, but by the same method the practitioner may do it for each 5 degrees, and then it will be more exact.

The courſe and diſtance from each of theſe places are found (by chapter 4. ſection 3. problem 2. of Mercator's Sailing, in pages 87, and 88.) in like manner, as in the third ſtep of the laſt problem, and is as followeth.

For the courſes the proportion is,

As mer. diff. lat. ·· diff. long. :: radius :: T. of the courſe required.

As 570 min. ·· 600 min. :: T. 45d. ·· T. 46d. 55m. S.W. from Z to a
725 — — —39d. 37m. } a to b
884 — — 34d. 10m. } S W from } b to c
1014 — — —30d. 28m. } c to d
As 281 min. :: 160 min. :: T. 45d. ·· T. 29d. 39m. } d to N.

2. For the diſtances, the proportion is

As S. c. courſe ·· diff. lat. ·· radius ·· diſtance repuired.

As S. 43d. 05m. ·· 390 min. :: S. 90d. ·· 571 min. from Z to a
50d. 23m. ·· 563 — 731 } a to b
55d. 50m. ·· 782 — 945 } from } b to c
59d. 32m. ·· 984 — 1141 } c to d
60d. 21m. ·· 281 — 323 } d to N.

This may ſerve for a ſufficient explanation of the problem, the whole is in the table following.

Places.	Place Latitude.	Meridional Parts.	Mer. Diff. Lat.	Difference of Longitude.	Diff. of Latit.	Courſes from Place to Place.	Diſtances of Places.
	d. m.	Min.	Min.	d. m.	d. m.	d. m.	Minutes.
Z	50.00	2374	570	10 or 600	6.30	S 46 55 W	571
a	43.30	2904	725	10 or 600	9.23	S 39 73 W	731
b	34 07	2179	884	10 or 600	3.02	S 34 10 W	945
c	21.05	1295	1014	10 or 600	16.24	S 30 28 W	1142
d	04.41	281	281	2.40 or 160	4.41	S 29 29 W	332
N	00.00	c		The whole Diſtance is——3712			

Caſe 3. The ſecond kind; *Both places in north, or in ſouth latitude, as for example.*

Problem 3. *Suppoſe the Lizard and iſland Barbadoes; I demand the angles of poſition? The Great Circle's diſtance between them? The latitude of the arch at every* 10 *degrees difference of longitude? With the courſe, and diſtance from each of them, according to Mercator?*

The

The latitude and longitude of these places supposed as follows:

		d. m.		d. m.
Lizard.	latit.	50.00	longit.	5.24 W
I. Barbadoes.		13.00		58.04 W
And their difference of longitude is				52.40 W

This problem is delineated Stereographically by the directions in problem 7. of Geography, in pages 171 and 172.

In the Oblique Spheric Triangle PZL plate 6. fig. 2.

1. Z represents the Lizard in latitude 50 degrees north.
2. L the island of Barbadoes, in latitude 13 degrees north.
3. The side PZ the complement of the latitude of the Lizard 40 degrees.
4. The side PL the complement of the latitude of Barbadoes, 77 degrees.
5. The angle ZPL their difference of longitude 52 degrees 40m.
6. PZL } the angle of position at { the Lizard.
7. PLZ } the angle of position at { island Barbadoes.
8. The side ZL the great circle's distance between them.

For the angle PZL and PLZ, (by chapter 5. section 5. problem 9. case 7. of Spheric Trigonometry, Oblique, in pages 134 and 135.) the proportions are these;

As the sine of half the sum of the complements of both latitudes, is to the sine of half their difference;

So is the tangent complement of half their difference of longitude, to the tangent of half their difference of the angle of position. Again,

As the sine complement of half the sum of the complements of both latitudes, is to the sine complement of half their difference;

So is the tangent complement of half their difference of longitude, to tangent of half the sum of the angles of position. But shorter thus.

As S. $\frac{1}{2}$ sum sides ·· S. $\frac{1}{2}$ their diff. :: T. c. $\frac{1}{2}$ ZPL ·· T. $\frac{1}{2}$ diff. of angles
As S. 58d. 30m. ·· S. 18d. 30m. :: T. 63d. 40m. ·· T. 37d. 02m.

Again,

As Sc. $\frac{1}{2}$ sum sides ·· S. $\frac{1}{2}$ their diff. :: T. c. $\frac{1}{2}$ ZPL. :: T. $\frac{1}{2}$ sum angles.
As S. 31d. 30m. ·· S. 71d. 30m. :: T. 63d. 40m. ·· T. 74d. 48m.
To which the $\frac{1}{2}$ diff. above being added — 37d. 02m.

The sum is the angle of position at Z — 111d. 50m.

And subtracted is the angle of position at L. — 37d. 46m.

For

For the ſide ZL. the diſtance, it's found (by chapter 7. ſection 2. caſe 3. problem 7. of Geography, in pages 172 and 173.) to be 56d. 23m. or 3383 minutes, which is their diſtance in the arch of a great circle.

To find the latitude by which the arch ſhall paſs, at every 10 deg. difference of longitude, from Z repreſenting the Lizard, deſcribe the problem gnomonically, and then all the parts of it will be right lines, which is thus done.

The problem gnomonically delineated.

1. Make the angle LPZ equal to 52d. 40m. the difference of longitude.

2. Make the ſide PZ equal to the tangent of 40 degrees, the complement of Lizard's latitude.

3. And PL equal to the tangent of 77 degrees the complement of Barbadoes latitude.

4. Draw the line LZ, which is the great circle's diſtance between them, and continue it beyond Z.

5. From P let fall the perpendicular P B, to cut LZ in B; which being meaſured on the ſcale of tangents, is 36d. 38m. the complement of the arch's greateſt latitude.

6. Then draw lines from P, each 10 degrees diſtant from Z; as Pa, Pc, Pd, Pe, and Pf, which are meridians, each 10 deg. of longitude from the Lizard, and from each other.

7. Meaſure Pa, Pc, &c. on the ſcale of tangents, and it ſheweth the complements of the latitudes of the arch, at the reſpective places, a, c, d, &c.

Theſe are found by calculation after this manner:

Firſt. In the rectangle ſpheric triangle P B Z; there is given the $\left\{\begin{array}{l}\text{hypot. PZ 40d. 0m.}\\ \text{angle PZB 68d. 10m.}\end{array}\right\}$ to find the $\left\{\begin{array}{l}\text{leg BP.}\\ \text{angle BPZ.}\end{array}\right.$

Which by chapter 5. ſection 4. problem 2. caſes 4 and 6 of Spheric Trigonometry Rectangular, in pages 126 and 127, is thus,

1. For the leg BP, the complement of the arches greateſt latitude it's thus;

As the radius is to the ſine complement of the greateſt given latitude;

So is the ſine of the angle of poſition (at that place) to the ſine complement of the arch's greateſt latitude. That is,

As radius ·· S. hypot. PZ :: S. angle PZB ·· S. leg PB.

As S. 90d. ·· S. 40d. 00m. :: S. 68d. 10m. ·· S. 36d. 38m. which being ſubtracted from ——— 90d. 00m.

Reſt the arch's greateſt latitude —— 53d. 22m.

2. For the vertical angle PBZ, it's thus;

As radius, is to the ſine of the greateſt given latitude;

So

So is the tangent of the angle of position (at that place,) to the tangent of the complement of the vertical angle: that is,
As radius ·· Sc. hyp. PZ :: T. angle PZB ·· Tc. angle BPZ.
As S. 90d. ·· S. 50d. 00m. :: T. 68d. 10m. ·· T. 62d. 23m. which being subtracted from —— 90d. 00m.

Rests the vertical angle BPZ —— 27d. 37m.

Secondly, to find the several latitudes of the arch at a, c, d, &c. you may consider, that the several pricked lines Pa, Pc. &c. are so many hypotenuses, to as many several Rectangle Spheric Triangles, which have one common leg PB, the complement of the arch's greatest latitude.

In each of them, there is given a leg, and its adjacent angle, to find the hypotenuse; that is, in the triangle PBA, there is given the leg PB, and angle BPa; to find the hypotenuse, Pa; and so in all the rest.

And the several vertical angles BPa, BPc, BPd, &c. are found by a continual addition of 10 degrees, to the angle BPZ, 27d. 37m. till the sum exceed not 80d. 17m. the difference of longitude given, added to the foresaid 27d. 37m. That is;

		d. m.
To the angle BPZ		27.37
Add the angle ZPa		10.00
Sum is the ang.	BPa	37.37
	BPc	47.37
	BPd	57.37
	BPe	67.37
	BPf	77.37

These vertical angles being thus found, the several latitudes of the arch at a, c, d, e, and f, are found by chapter 5. section 4. problem 3. case 9. of Spheric Trigonometry Rectangular, in pages 126 and 127, the proportion being the same as before, in case 2. problem 1. of this chapter, in pages 175, 188, and is as followeth.

As radius, is to the sine complement of the vertical angles, so is the tangent of the arch's greatest latitude, to the tangent of the arch's latitude required. Or thus;

As radius ·· SCc. BPa, BPC, &c. :: Tc. leg BP ·· Tc. Pa, Pc, &c.

As S. 90d. ·· S. 52d. 23m. :: T. 53d. 22m. T.	46.49	lat. of	a
42d. 23m.	—	42.11		c
32d. 23m.	—	35.46		d
22d. 23m.	—	27.07		e
12d. 23m.	—	16.05		f

Which latitudes place in the table following.

Places

Places	Places Latitudes.	Meridional Parts.	Mer. Diff. Lat.	Difference of Longitude.	Diff. of Lat.	Courses from place to place	Distances of places.
	d. m.	Min.	Min.	d. m.	d. m	d. m.	Min.
Z	50.00	3474					
a	46.49	3187	287	10 or 600	3.11	S 64 22 W	441
c	42.11	2796	391	10 or 600	4.38	S 56 55 W	509
d	35.46	2301	495	10 or 600	6.25	S 50 29 W	605
e	27.07	1691	610	10 or 600	8.39	S 44 32 W	728
f	16.05	978	713	10 or 600	11.02	S 40 05 W	865
L	13.00	787	191	92.40 or 160	3.05	S 38 08 W	235
				The whole Distance			3383

Thirdly, The course and distance in the two last columns of this table, are found by chapter 4. section 3. problem 2 .of Mercator's Sailing, in pages 87 and 88, in the same manner as in the two last problems in this chapter ; thus,

1. For the courses, the proportion is,

As mer. diff. lat. ·· diff. long. :: radius T. ·· of the course required.

As 287 min. ·· 600 min. :: T. 45d. ·· T. 64d. 22m. SW from Z to a

391	—	—	— 56d. 55m.	S.W. from		a to c
495	—	—	— 50d. 29m.			c to d
710	—	—	— 44d. 32m.			d to e
713	—	—	— 40d. 05m.			e to f
As 191 min.	·· 160 min.	:: T. 45d.	·· T. 38d. 08m.			f to L

2. For the distances the proportion is,

As Sc. course ∴ diff. lat. :: radius .. distance required.

As S. 25d. 38m. ·· 191 min. :: S. 90d. ·· 441 min. from Z to a

33d. 05m. ·· 278	—	—	509	from	a to c
39d. 31m. ·· 385	—	—	605		c to d
45d. 28m. ·· 519	—	—	728		d to e
49d. 55m. ·· 662	—	—	865		e to f
51d. 52m. ·· 185	—	—	235		f to L

Thus is this third problem sufficiently explained in every part of it.

Case 3. The third kind ; *One place in north latitude, and the other in south latitude, as for example.*

Problem 4. *Suppose Cape Cod in New England and Cape Bona Esperance: I demand the angle of position? the great circles distance between them? the latitude of the arch at every 10 degrees difference of longitude? the course and distance from them according to Mercator?*

The

The latitude and longitude of these places supposed to be as follows;

			D. M.			D. M.	
Cape Cod	{ lat.	{	42 10	N. {	longit.	{ 67 45	W.
Cape Bona Esper.			34 25	S.		17 10	
Their sum of longitudes			—		—	84 55	

In the oblique spheric triangles PZD, plate 7. fig. 1.

1. Z represents cape Cod in the latitude 42d. 10m. north.
2. D represents cape Bon. Esper. in latitude 34d. 25m. south.
3. The side PZ the complement of the latitude of C. Cod, 47d. 50m.
4. The side PD the distance of cape Bon Esperance, from the north pole, or it's latitude added to 90d. equal to 124d. 25m.
5. The ang. ZPD their sum of longitudes, 84d. 55m.
6. PZD } the angle of position at cape { Cod,
7. PDZ } { Bona Esperance.
8. The side ZD the great circle's distance between them.

For the angles PZD, and PDZ, (by chapter 5. section 5. problem 9. case 7. in pages 133 and 134, the proportions are these;

	d. m.				d. m.
Side PD	124 25			The angle DPZ	84 55
Side PZ	47 50				
			d. m.	The half of it is	42 27
The sum	172 15	the ½ sum	86.07	Which subt. from	90 00
The diff.	76 35	the ½ diff.	38.17	Its complement	47 53

As S. ½ sum sides .. S. ½ their diff. :: T.c. ½ ZPD .. T. ½ diff. ang. req.
As S. 86d. 07m. .. S. 38d. 17m. :: T. 47d. 33m. .. T. 34d. 10m.
As S. 03d. 53m. .. S. 51d. 43m. — T. 85d. 29m.

Added, giveth the greater angle PZD — 119d. 39m.
Subtracted, is the lesser angle PZD — 51d. 19m.

The distance ZD is found (by chapter 7. section 2. case 3. problem 8. of Geography) in page 174. to be 108d. 59m. or 6539 minutes.

To find the latitudes by which the arch shall pass, at each 10 degrees difference of longitude from Z, representing cape Cod; describe the problem Stereographically on the plane of the equator, and then all the meridians will be right circles

To delineate the problem stereographically, plate 6. fig. 3.

1. Describe the primitive circle and make the angle DPZ equal to 84d. 55m. the sum of longitudes by chapter 5. section 1. problem 2. case 2. (in page 104) of Spheric Geometry, by drawing two right circles.
2. Make the side PZ equal to the half-tangent of 47d. 50m. the complement of the latitude of cape Cod.

3. And

3. And PD equal to the half-tangent of 124d. 25m. (the latitude of cape Bon Eſperance added to 90d.) by chap. 5. ſection 1. prob. 6. caſe 2. of Spheric Geometry, in pages 108 and 109.

4. Then by chapter 5. ſection 1. problem 4. of Spheric Geometry (in pages 105 and 106) through Z and D draw a great circle.

5. From P (by problem 5. of Spheric Geometry, in page 106.) let fall the perpendicular PB, to cut ZD in B; which being meaſured on the ſcale of half-tangents, is 40d. 06m. the complement of the arch's greateſt latitude.

6. Then draw lines from P, each 10d. diſtant from Z; as Pa, Pc, Pd, Pe, &c. which are meridians each 10d. of longitude from one another, and from the meridian of cape Cod.

7. Meaſure Pa, Pc, &c. on the ſcale of half-tangents, and it ſheweth the complement of the latitude's of the arch at the reſpective places a, c, d, &c.

Theſe are found by calculation after this manner, which is in all reſpects like the work of the laſt problem.

Firſt. In the rectangle ſpheric triangle PBZ.

1. For the leg BP, the complement of the arch's greateſt latitude it's thus;

As radius ∙∙ S. hypot. PZ :: S. angle PZB ∙∙ S. leg PB.
As S. 90d. ∙∙ S. 47d. 50m. :: S. 61d. 21m. ∙∙ S 40d. 06m.
Which ſubtract from — 90d. 00m.

Reſts the arch's greateſt latitude — 49d. 54m.

2. For the vertical angle PZB it's thus;

As radius ∙∙ Sc. hypot. PZ :: T. angle PZB ∙∙ Tc. angle PBZ.
As S. 90d. ∙∙ S. 42d. 10m. :: T. 61d. 21m. ∙∙ T. 49d. 13m.

Reſt the vertical angle BPZ —— 40d. 18m.

Secondly, For the ſeveral latitudes at a, c, d, &c. add 10d. to the angle PBZ (in continuation) eight times, which produceth the ſeveral vertical angles, BPa, BPc, BPd, &c.

		d. m.
To the angle BPZ —		40.18
Add the angle ZPA —		10.00
Sum is the angle	BPa	50.18
	BPc	60.18
	BPd	70.18
	BPe	80.18
	BPf	90.18
	BPg	100.18
	BPh	110.18
	BPi	120.18

Theſe vertical angles being thus found, the ſeveral latitudes of the arch, at a, c, d, e, f, g, h, and i, are found by chapter 5. ſection 4. problem 3. caſe 9. of Spheric trigonometry Rectangular; the proportions being the ſame as before in caſe 2. problem 1. of this chapter, in pages 178 and 179, as follows.

As

As the radius, to the sine complement of the vertical angle;
So is the tangent of the arch's greatest latitude, to the tangent of the arch's latitude required. Or thus,
As radius ·· Sc. BPa, BPc, &c. :: Tc. leg BP ·· Tc. Pa, Pc, Pd, &c.

				d. m.		
As S. 90d. ·· S.	39d. 42m.	:: T. 49d. 54m. ·· T.		37.11	Latitude of	a
	29d. 42m.	—		30.26		c
	19d. 42m.	—		21.49		d
	09d. 42m.	—		11.19		e
	00d. 18m.	—		00.21		f
	10d. 18m.	—		11.59		g
	20d. 18m.	—		22.23		h
	30d. 18m.	—		30.56		i

Thirdly, For the courses, and distances, they are found by chapter 4. section 3. problem 2. of Mercator's Sailing, in pages 87 and 88, as follows,

For the courses, the proportion is,
Mer. diff. lat. ·· diff. long. :: radius ·· T. course

As 389 min. ··	600 min. ::	T. 45d. ··	T. 57d.03m.	S E. from	Z to a
485	—	—	51d.03m.	from	a to c
578	—	—	46d.04m.		c to d
660	—	—	42d.16m.		d to e
704	—	—	40d.26m.		e to f
702	—	—	40d.31m.		f to g
655	—	—	42d.30m.		g to h
574	—	—	46d.16m.		h to i
As 346 min. ··	295 min. ::	T. ··	45d.59m.		i to D

2. For the distances, the proportion is
As Sc. course ·· diff. lat. :: radius ·· distance required.

As S.	32d. 57m. ··	299 m. ::	S. 90 ··	550	min. from	Z to a
	38d. 57m. ··	403	—	941	from	a to c
	43d. 56m. ··	519	—	748		c to d
	47d. 44m. ··	630	—	851		d to e
	49d. 34m. ··	700	—	920		e to f
	49d. 29m. ··	698	—	918		f to g
	47d. 30m. ··	624	—	847		g to h
	43d. 44m. ··	513	—	724		h to i
	75d. 10m. ··	209	—	324		i to D

Which

Which place orderly as in the table following, and it's finiſhed.

Places	Places Latitude.	Meridian Part.	Mer. Di Laſſ	Difference of Longitude.		Difference of Latitude.		Courſes from place to place.	Diſt. of Place
	d. m.	Min.	Min.	d.	m.	d.m.	m.	d. m.	Min.
Z	42.10N	2795							
a	37.11	2406	389	10 or	600	4.59 or	299	S 57.03 E	551
c	30.28	1921	485	10 or	600	6.43 or	403	S 51.03 E	641
d	21.49	1343	578	10 or	600	8.39 or	519	S 46.04 E	748
e	11.19N	683	660	10 or	600	10.34 or	630	S 42.16 E	851
f	00.21 S	21	704	10 or	600	11.40 or	700	S 40.26 E	920
g	11.59	724	703	10 or	600	11.38 or	698	S 40.31 E	918
h	22.23	1379	655	10 or	600	0.24 or	624	S 42.30 E	847
i	20.56	1953	574	10 or	600	8.33 or	513	S 46.16 E	742
D	34.25	2202	249	4 55 or	295	3.29 or	209	S 49.50 E	324
								The whole diſtance is	0541

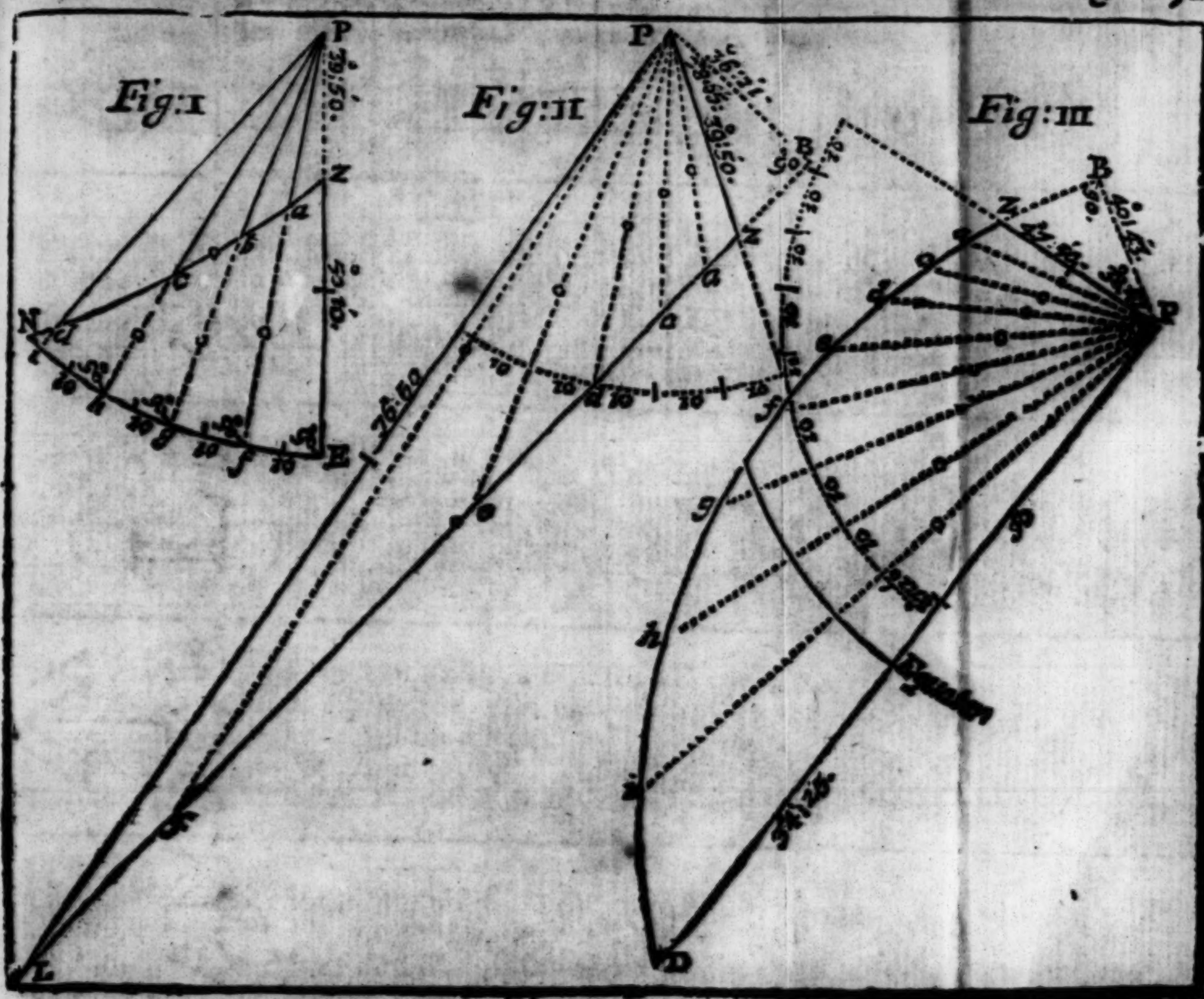
Note; The arch of a great circle may be deſcribed on a Mercator's chart, and thereby much of the calculative work may be ſpared; for having the ſeveral latitudes of the arch at every 5 or 10 degrees difference of longitude, (by chapter 4. ſection 1. problem 1 and 2. of the uſe of Mercator's chart, in pages 79 and 80, thoſe places may be pricked down in the chart, and then with a black lead pencil draw lines from place to place, which will repreſent the great circle, and by problems 3 and 4, of the uſe of that chart, in page 80, the courſes and diſtances from each other may be found, and at any time thoſe lines may be wiped out, and the chart as fit to ſerve at any other time as before.

So that any problem being thus drawn, in a Mercator's chart, the nearer the ſhip ſails to it, the nearer to a great circle ſhe makes her way good, and conſequently the ſhorter her paſſage, the only thing great circle ſailing is uſeful for, of which I have ſaid enough to explain it.

Thus it finiſhed the Third Part of Navigation, or the Third kind of Sailing, and now we paſs on to Aſtronomy.

CHAP.

Plate 6. Place this next after Page 192.



CHAP.

CHAP. IX. *Spheric trigonometry applied in sundry Astronomical Problems, useful in the art of navigation.*

WHat a Sphere or Globe is, and the circles generally drawn on it, hath been taught (chapter 6. sections 2 and 3.) in the description of both globes: but how these are drawn on a plane, and form divers triangles, from whence multitudes of useful and pleasant problems may be framed, is our present work.

Section I. *Astronomical definitions.*

THe Circles drawn upon the sphere's surface, are either great or lesser circles.

I. The great circles, and their poles described.

Great circles, are those which divide the globe, or sphere into two equal parts, and are principally these six; the equinoctial, ecliptic, meridian, horizon, azimuth, and circle of longitude.

1, The Equinoctial is a great circle which lies in the middle, between the two poles of the world, and consequently each pole is 90 degrees distant from it, cutting all meridians at right angles, and divides the world into the northern and southern hemispheres, as the right circle ÆAQ. Plate 7. fig. 1 and 2.

The poles of the world are two fixed points in the heavens, diametrically opposite to each other, the one in the Northern Hemisphere, called the (artic or north pole, the other in the South hemisphere, called the (antartic or) south pole as P and I. Plate 7. fig. 1 and 2.

The Axis of the world, is an imaginary line drawn from pole to pole, about which the diurnal motion (as supposed) from east to west is performed; as PAI.

2. The Ecliptic (is a great circle) crossing the equinoctial in (two opposite points,) the beginning of Aries and Libra, making an angle (called its obliquity) of 23d. 30m. as the right circle, by ♋ A♑ plate 7. fig. 1.

This circle is divided into 12 equal parts called signs, each containing 30d. whose names and characters follow.

Aries	♈	northern signs	Libra	♎	southern signs
Taurus	♉		Scorpio	♏	
Gemini	♊		Sagittarius	♐	
Cancer	♋		Capricornus	♑	
Leo	♌		Aquarius	♒	
Virgo	♍		Pisces	♓	

The Zodiack, is a zone or girdle, having eight degrees of latitude on each side the ecliptic; in which space, the planets make

make their revolutions, being divided and diſtinguiſhed by the twelve ſigns.

The Poles of the ecliptic, are two oppoſite points 23d. 30m. diſtant from the poles of the world; as K and L.

3. The Meridians (are great circles) paſſing through both poles of the world, and croſſeth the equinoctial at right angles, as PÆI, and PMI, &c. Plate 7. fig. 1 and 2.

The Colures are two meridians dividing the equinoctial and ecliptic into four equal parts; one of theſe paſſeth by the equinoctial points, Aries and Libra, and is called the equinoctial colure, as PAI. Plate 7. fig. 1 and 2.

The other paſſeth by the beginning of Cancer and Capricorn, and is called the Solſtitial Colure; as P ♋ ÆI ♑ Q. Plate 7. fig. 1.

The Sun's Meridian, is that meridian which paſſeth over the ſun's center.

A ſtar's meridian, is that meridian which paſſeth through the middle of that ſtar.

4. The Horizon is a great circle of 90 degrees diſtant from the zenith and nadir, cutting all azimuths, at right angles, and dividing the world into two equal parts, the upper and viſible hemiſphere, and the lower and inviſible hemiſphere. This circle is repreſented by the right circle SAB. Plate 7. fig. 2.

The Zenith and nadir are two points diametrically oppoſite, and are the poles of the horizon: the zenith is the vertical point, or point right over our heads as Z: the nadir is directly oppoſite thereto, as N. Plate 7. fig. 2.

5. The Azimuth, or Vertical circles, (are great circles) concurring and interſecting each other in the zenith and nadir, and croſs the horizon at right angles, as ZNC, and ZAN, &c.

The Prime Vertical, is that azimuth circle, which paſſeth through the eaſt and weſt points of the horizon, as the right circle ZAN.

The Meridian of a Place, is that meridian which paſſeth through the poles of the world, as the zenith and nadir of the ſaid place, as ZPBNISÆZ. Plate 7. fig. 2.

6. Circles of longitude, (are great circles) interſecting each other in the poles of the ecliptic, as KAL, and KUL, plate 7. figure 1.

II. *The leſſer circles defined.*

Leſſer or ſmall circles, are thoſe which divide the ſphere into two equal parts, and are drawn parallel to ſome great circle, and therefore are called parallel circles; and are of three kinds, *viz.* Parallels of Declination, Parallels of Latitude, and Parallels of Altitude.

1. Paral-

1. Parallels of Declination, (are small circles) parallel to the equinoctial, imagined to pass through every degree and minute of the meridian, between the equinoctial and each pole of the world, as ♋ f g, and ♑ h i. Plate 7. fig. 1 and 2.

The Tropicks are two parallels of declination 23d. 30m. distant from the equinoctial, limiting the sun's greatest declination.

The north Tropic, passeth by the beginning of cancer, and is called the Tropic of Cancer, as ♋ f g. Plate 7. fig. 1 and 2.

The South Tropic, passeth by the beginning of Capricorn, and is called the Tropic of Capricorn; as ♑ h i. Plate 7. fig. 1 and 2.

The polar circles, are two parallels of declination 66d. 30m. distant from the equinoctial, and 23d. 30m. from each pole of the world.

That which is adjacent to the north pole is called the Artic Circle; as K n o; and the other the Antartic Circle; as L p r. Plate 7. fig. 1 and 2,

2. Parallels of latitude are (small circles) parallel to the ecliptic, imagined to pass through every degree and minute of the colures, between the ecliptic and poles thereof, as w x y.

3. Almicanters, or parallels of altitude, are small circles parallel to the horizon, imagined to pass through every degree and minute of the meridian, between the horizon and the zenith; as a l t. Plate 7. fig 2.

These definitions compared with chap. 6. sect. 4. (of the use of the cœlestial globe, in pages 155 and 156.) and well considered, will make way for the understanding the following problems.

Sect. II. *Spheric trigonometry rectangular, applied in astronomical problems, useful in navigation.*

AND because the sun's place in the ecliptic, is the ground of the succeeding problems, you have here (out of Mr. Tho. Street's Memorial Verses on the ecclesiastical and civil calendar) a general rule; which for common uses may serve, and is as follows.

1. *To know the day of the month the sun entereth any of the Twelve Signs.*

The rule, Twice 9, twice 10, 4 twelves, 11;
Then 10, then 9, then 8 or 7.

That is, counting March the first month, the sun enters

♈	March	9	♌	July	12	♐	November	11
♉	April	9	♍	August	12	♑	December	10
♊	May	10	♎	September	12	♒	January	9
♋	June	10	♏	October	12	♓	February	8

2. *To find the degree of the sun's place on any given day.*

The rule. From the day of the month given (if you can) subtract the day of his entrance into the Sign of that month, the remainder is the degree of the sun's place in that sign. Or else,

When you can't subtract, add 30 to the day given, and from the sum subtract the day of the entrance into the Sign of that month, the remainder shall be the degree of his place in the Sign preceeding the month given.

Example 1. March 20th, I desire to know the sun's place?

From March the 20th, the day given, subtract the sun's entrance ♈ March 9.

The remainder 11 is the degree of the sun's place in ♈

Example 2. May the 4th, I desire to know the sun's place?

To the day given May the 4th.

Add — — — — 30

Sum is — — — 34 from which

Subtract the sun's entr. into ♊ May 10

Remainder is the sun's place ♉ —24 degrees.

Problem 1. The sun's place in the ecliptic, and his greatest declination given; to find his right ascension, and present declination.

Definition 1. Ascension, is the rising of the sun, star or any part of the equinoctial above the horizon; and descention is the setting thereof.

2. Right Ascension, is an arch of the equinoctial, intercepted between the beginning of ♈ and any meridian, and counted according to the order or succession of the signs; or it's that degree and minute of the equinoctial (counted as before) which cometh to the meridian with the sun, star or with any part of the ecliptic; as AM. Plate 7. fig. 1.

3. Declination, is an arch of a meridian contained between the sun, or star's center, and the equinoctial, as MC.

4. The sun's greatest declination is an arch of the solstitial colure, counted between the equinoctial and the ecliptic, and is 23d. 30m. as Æ ♋, and Q ♑ plate 7. fig. 1.

Example. The sun in Taurus, 24d. 15m. I demand his right ascension and declination.

In the rectangle spheric triangle AMC. Plate 7. fig. 1.

1. AMC the right angle.
2. AC the sun's longitude from the next equinoctial point.
3. AM his right ascension from the same point.
4. MAC the sun's greatest declination equal to 23d. 30m.
5. MC his present declination.

Note, The sun in ♈, ♉, ♊, ♑, ♒, ♓, the nearest equinoctial point is the beginning of ♈; but when the sun is in ♋, ♌, ♍, ♎, ♏ or ♐, the nearest equinoctial point is ♎. So

So that in this problem the sun being in ♉, 24d. 15m. he is 54d. 15m. from the nearest equinoctial point ♈.

To project this problem Stereographically on the plain of the solstitial colure.

1. Describe the primitive circle with a chord of 60 degrees, and quarter it, with two right circles, ÆAQ (the equinoctial) and PAI (the equinoctial colure) placing A at the center of that primitive circle, which now is the solstitial colure.

2. Make (by problem 2. case 1. of Spheric Geometry, in page 104) the angle ÆA ♋, equal to 23d. 30m. (the sun's greatest declination) by laying the chord of it, from Æ to ♋, and drawing the right circle ♋ A ♑ the ecliptic.

3. The ecliptic is divided into the 12 signs, each being 30d from the scale of half tangents by problem 6. case 2. of Spheric Geometry in pages 108 and 109.

4. On the ecliptic make AG equal to 54d. 15, from the scale on half tangents by the same problem 6. case 2.

5. Then (by chapter 5. section 1.) problem 5. case 3. of Spheric Geometry in page 106, draw from C a great circle perpendicular to ÆAQ, as is the oblique circle PCMI, to cut ÆAQ in M, and it's done.

For in the rectangle spheric triangle AMC, the legs AM, and MC are the two things required, and may be measured by chapter 5. section 1. problem 7. cases 2 and 3. of Spheric Geometry in page 109.

But by Spheric Trigonometry, having the hypotenuse and one angle given, the proportions are as follow.

1. To find the sun's right ascension, by chapter 5. section 4. problem 2. case 5. of Spheric trigonometry Rectangular, in pages 104 and 105, it's thus;

As the radius is to the sine complement of the sun's greatest declination;

So is the tangent to the sun's longitude from the nearest equinoctial point, to the tangent of his right ascension from the said point. Or thus;

As radius ·· Sc. angle MAC :: T. hypot. AC ·· T. leg AM.

As S. 90d. ·· S. 66d. 30m. :: T. 54d. 15m. ·· T. 51d. 52m.

Note; This proportion finds the sun's right ascension only when he is in the first quarter of the ecliptic; that is, in ♈, ♉, or, ♊: but when the sun is in the second quarter ♋ ♌, or ♍, it must be subtracted from 180d. and when he is in ♑ ♒ or ♓ that found by this proportion, must be subtracted from 360d. and so will you have the sun's right ascension from ♈, (for any place in the ecliptic) desired.

2. To find the sun's present declination, by chapter 5. section 4. problem 2. case 4. of Spheric Trigonometry Rectangular, page 104, it's thus;

As the radius is to the sine of the sun's longitude from the nearest equinoctial point;

So is the sine of his greatest declination, to the sine of the sun's present declination. Or thus;

As radius ·· S. hypot. AC :: S. angle MAC ·· S. leg CM.

As S. 90d. ·· S. 54d. 15m. :: S. 23d. 30m. ·· S. 18d. 51m.

Note; The sun being in any of the north signs, ♈, ♉, ♊, ♋, ♌, or ♍, his declination is north; but when in any of the southern signs ♎, ♏, ♐, ♑, ♒, or ♓, his declination is south.

In this rectangle spheric triangle A M C (plate 7. figure 1.) may the two next succeeding problems be resolved.

Problem 2. *The Sun's Right Ascension given; to find his place in the ecliptic, and his declination?*

Example. *The Sun's Right Ascension* 128d. 9m. *where is his place in the ecliptic, and what is his declination?*

Here is one leg and its adjacent angle given: to wit, the leg AM 51d. 51m. the right ascension (subtracted from 180d. and angle MAC 23d. 30m. the sun's greatest declination; which triangle is made by problem 12. of Spheric Trigonometry Geometrical in page 112. and its solution is by chapter 5. section 4. problem 3. cases 7, 8, and 9. of Spheric Trigonometry Rectangular, in pages 127 and 128. thus;

1. For the sun's place in the ecliptic it's thus;

T. leg. AM ·· radius :: S. c. angle MAC ·· T. c. hipot. AC or

As radius ·· S. c. angle MAC :: T. c. leg AM ·· T. c. hipot. AC rqe.

As S. 90d. ·· S. 66d. 30m. :: T. 38d. 90m. ·· T. 35d. 46m.

Which subtract from — — — 90d. 00m.

Resteth the sun's longitude — — 54d. 14m. wanting of ♎, so that his place is 5d. 46m. in ♌.

2. For his present declination, it's thus;

As T. c. angle MAC ·· radius :: S. leg AM ·· T. leg MC. or

As radius ·· S. leg AM :: T. angle MAC ·· T. leg. MC.

S. 90d. ·· S. 51d. 51m. :: T. 23d. 30m. ·· T. 18d. 52m. the sun's declination north decreasing.

Problem 3. *The Sun's Declination given; to find his Place in the Ecliptic and Right Ascension.*

Example. *The Sun's Declination* 16d. 39m. *south increasing: I demand his Place in the Ecliptic and Right Ascension.*

Here is a leg and its opposite angle given; that is the angle MAC 23d. 30m. the sun's greatest declination, and the leg MC 16d. 39m. his present declination, which triangle is made by problem 13. of Spheric Trigonometry Geometrical, in page 116, whose

Solution

Solution is by chap. 5. sect. 4. prob. 4. cases 10 and 12. of Spherical Trigonometry Rectangular, in pages 128 and 119, thus;

1. To find his place in the Ecliptic, it's thus;

As S. angle MAC ∙∙ radius :: S. leg. MC ∙∙ S. hipot. AC.
As S. 23d. 30m. ∙∙ S. 90d. :: S. 16d. 39m. ∙∙ S. 45d. 56m. the sun's longitude beyond ♎, because his declination is south increasing; so that the sun's place is 15d. 56m. in ♏.

2. For his Right Ascension it's thus;

Radius ∙∙ T. c. angle MAC :: T. leg MC :: S. leg AM.
T. 45d. ∙∙ T. 66d. 30m. :: T. 16d. 39m. ∙∙ S. 43d. 27m.
to which add — — — 180d. 00m.

The sum is the Sun's right ascension 223d. 27m. from ♈.

Problem 4. *The latitude of a place, and the sun's declination given; to find his amplitude and ascensional difference.*

Definition 1. Latitude of a place, or Latitude upon the earth, is an arch of the meridian of that place, contained between the zenith (of that place) and the equinoctial, as ZÆ; equal thereunto is the height of the pole above the horizon, as BP. plate 7. fig. 2.

2. Amplitude, is an arch of the horizon, contained between the ecliptic and the equinoctial, and sheweth how far the sun, or any star riseth, or setteth from the east or west points of the horizon; as AR, plate 7. fig. 2.

3. Ascensional Difference, is the difference between the right ascension, and the oblique ascension, or descension: or it's an arch of the equinoctial contained between the hour circle of six o'clock, and that meridian which passeth by the Sun or Star's center, or any point of the ecliptic, in their rising, or in their setting.

4. Oblique $\left\{\begin{array}{l}\text{Ascension}\\\text{Descension}\end{array}\right\}$ is an arch of the equinoctial contained between the beginning of ♈, and that part of the equinoctial that $\left\{\begin{array}{l}\text{riseth}\\\text{setteth}\end{array}\right\}$ with the center of the Sun or Star, or with any point, part, or portion of the Ecliptic, in an Oblique Sphere.

Example.

	d. m.		
Latitude	51 32	North given; what is his	amplitude,
Sun's dec.	23 30		ascens. differ.

In the rectangle spheric triangle PBR, plate 7. fig. 2.

1. PBR the rectangle.
2. PB the latitude, or height of the pole above the horizon.
3. PR the compliment of the Sun's declination.
4. BR the complement of the Sun's amplitude.
5. BPR the complement of the Sun's ascensional difference.

To project it stereographically on the plain of the meridian.

 1. The

1. The primitive circle being described and quartered as (formerly) with two right circles SAB the horizon, and (ZAN) the prime vertical; with A at its center. Plate 7. fig. 2.

2. On the Primitive Circle lay the latitude 51d. 32m. from B to P, and from Z to Æ, (by problem 6. case 1. of Spheric Geometry, in page 116.) and draw the two right circles PAI for the axis of the world, and hour-circle of six, and ÆAQ the equinoctial.

3. Then (by problem 9. case 2. of Spheric Geometry, in page 112.) draw ♋ ☉ if Rg parallel to ÆAQ at 23d. 30m. the given declination) from it, to cut the horizon SAB in R, the place of the Sun's rising and setting.

4. Through P, R, I, draw an oblique circle and it's done:

For in the rectangle spheric triangle PBR. the leg BR, and angle BPR are the two things required, and may be measured by problem 7 and 8. of Spheric Geometry, in pages 107, 109, and 110.

But by trigonometry, having the hypotenuse PR 66d. 30m. and leg BP 51d. 32m. given, the proportions by chap. 5. section 4. problem 1. cases 1 and 3. of Spheric Trigonometry Rectangular in pages 125 and 126. is thus:

1. To find the Sun's Amplitude, the proportion is,

As the sine complement of the latitude, is to the radius,

So is the sine of the Sun's declination, to the sine of his amplitude. Or thus;

As S. c. leg BP ·· radius :: S. c. hyp. PR ·· S. c. leg. BR.

As S. 38d. 28m. ·· S. 90d. :: S. 23d. 30m. ·· S. 39d. 52m.

Note, The amplitude and declination are ever of one name; that is, both north or both south.

2. To find the ascensional difference, the proportion is;

As the radius, is to the tangent of the latitude,

So is the tangent of the Sun's declination to the sine of the Sun's ascensional difference. Or thus;

As radius ·· T. leg BP. :: T. c. hyp. PR ·· S. c. angle BPR.

As T. 45d. ·· T. 51d. 32m. :: T. 23d. 30m. :: S. 33d. 11m. the sun's ascensional difference.

Problem 5. *The latitude of a place, and the sun's declination given, to find the oblique ascension or descension.*

The rule 1. Find the right ascension by problem 3. and the ascensional difference by problem 4. Then,

2. When the latitude and declination are both north, or both south, the ascensional difference added to, and subtracted from the sun's right ascension, the first is the oblique descension, the latter the oblique ascension.

3. When

3. When the latitude and declination is one north, and the other south, add, and subtract as before; the first is the oblique ascension, and the latter is the oblique descension.

Note, When you cannot subtract, add 360 degrees to the right ascension, and then subtract, also when you have added, if the sum exceed 360 degrees, subtract 360 degrees therefrom, the remainder is the thing required.

Example. *Latit.* 51d. 32m. *north* ——— } *given, what is his sun's declin.* 15d. 40m. *south decreasing* } *Oblique Ascension, and Descension?*

1. For his right ascension it's thus;

As radius ·· T. c. angle MAC :: T. leg MC .. S. leg. AM req.
As T. 45d. ·· T. 66d. 36m. :: T. 15d. 40m. .. S. 40d. 04m.
Which subtracted from ——— ——— 360d. 00m.
Remainder is the sun's right ascension —319 56 from ♈.

2. For his Ascensional Difference, it's thus;

As radius .. T. latitude :: T. declin. .. S. ☉ ascensional dif.
As T. 45d. .. T. 51d. 32m. :: T. 15d. 40m. .. S. 20 41
Right ascension before found — 319 56 from ♈.
Added is the oblique descension — 340 37
Subtracted is the oblique ascension — 299 15

Problem 6. *The latitude and the sun's declination given; to find the sun's rising and setting; and the length of the day or night.*

The rule 1. Find the sun's ascensional difference by problem 4. in pages 200, and 201, which reduced into time, by allowing as hereunder.

15d. 00m.	for	1.—hour——	of time;
1d. 00m.		0.04 minutes	
0d. 15m.		0.01 minute	

2. The sun's ascensional difference (being reduced into hours and minutes) added to, and subtracted from six hours, the one is Sun Rising, and the other is his Setting.

Note, When the latitude, and declination are both north or both south; the sun rises before, or sets after six. But if one be north, and the other south; he then rises after, and sets before six of the clock.

3. Double the time of the sun setting gives the length of the day, also double the time of sun rising gives the length of the night.

Example. *In Latitude* 51d. 32m. *North, and the Sun's Declination* 23d. 30m. *North; the Sun's Ascensional Difference, by Problem* 4. *is* 33d. 11m. *equal in time to* 2 *hours* 13 *minutes. Therefore the work is as follows.*

d. m

	d. m.	6 Hours,		
Ascen. Diff.	33.11	Or 2 13		h. m.
Add, is Sun Setting		8 13	And length of the day	16 26
Subtract, is Sun Rising		3 47	And length of the night	7. 34

In the same rectangle spheric triangle PBR (plate 7. fig. 2.) may the five next following problems be resolved; which is for the learner's exercise.

Problem 7. Latitude of a place, and the sun's ascensional difference given; to find his declination and amplitude.

Example. The { latitude ———— 41d. 47m. south. / sun setteth at—— 7d. 30m.

Here is a leg and its adjacent angle given; that is, the leg BP 41d. 47m. the latitude, and the angle BPR 4h. 30m. or 67d. 30m. the complement of the sun's ascensional difference; which triangle is made by prob. 12. of Spheric Trigonometry Geometrical, in page 116. and for its solution, see chapter 5. section 4. problem 3. cases 8 and 9. of Spheric Trigonometry Rectangular, in pages 127 and 128, is thus;

1. For the sun's declination, it's thus;

As radius ·· S. ☉ asc. diff. :: T. c. latitude ·· T. ☉ decl. req.
As S. 90d. ·· S. 22d. 30m. :: T. 48d. 13m. ·· T. 23d. 11m. N.

2. For the sun's amplitude, it's thus;

As T. ☉ asc. diff. ·· radius :: S. latitude ·· T. c. ☉ ampli. Or
As S. latitude ·· radius :: T. ☉ asc. diff. ·· T. ☉ amplit.
As S. 41d. 47m. ·· S. 90d. :: T. 22d. 30m. ·· T. 31d. 52m.

Problem 8. Latitude and sun's amplitude given; to find his declination and ascensional difference.

Example. The { latitude———— 36d. 17m. north. / sun's altitude—— 19d. 11m. south.

Here are both the legs given; that is the leg SI 36d. 17m. the latitude, and the leg SR 70d. 49m. the complement of the sun's amplitude; which triangle is made by problem 14. of Spheric Trigonometry Geometrical, in page 117. and its solution is by chapter 5. section 4. problem 5. cases 13 and 14. of Spheric Trigonometry Rectangular in pages 128 and 129, in this manner.

1. For the sun's declination, thus;

As radius ·· S. c. latitude :: S. ☉ amplit. ·· S. ☉ declinat. req.
As S. 90d. ·· S. 53d. 43m. :: S. 19d. 11m. ·· S. 15d. 21m. south.

2. For his ascensional difference, it's thus;

As T. c. ☉ am. ·· radius :: S. latitude ·· T. ☉ asc. diff. Or
As radius ·· S. lat. :: T. ☉ amplit. ·· T. ☉ asc. diff.
As 90 deg. ·· S. 36° 17 :: T. 19d. 11m. ·· T. 11d. 38m. or 0h. 47m.

Prob-

Problem 9. The sun's declination, and amplitude given; to find the latitude and sun's ascensional difference.

Example. The sun's { declination —— 19d. 10m. south.
amplitude —— 31d. 30m. south.

Here is the hypotenuse, and one leg given; for which see problem 10. of Spheric Trigonometry Geometrical, in page 114. and chapter 5. section 4. problem 1. cases 2 and 3. of Spheric Trigonometry Rectangular, in pages 125 and 126, for it's solution.

Note; The latitude may be either north or south, in this problem.

Problem 10. Sun's declination, and ascensional difference given; to find the latitude, and his amplitude.

Example. Sun's { declination —— 23d. 30m. south.
setting at — —3h. 30m.

Here is the hypotenuse and one angle given; for which see problem 11. of Spheric Trigonometry Geometrical, in page 109 and 110, and chapter 5. section 4. problem 2. cases 4 and 5. of Spheric Trigonometry Rectangular, in pages 126 and 127. For its solution.

Problem 11. Sun's amplitude, and ascensional difference given; to find the latitude and his declination.

Example. Sun's { amplitude ———— 33d. 20m. north.
setteth at ———— 7h. 47m.

Here is one leg, and its opposite angle given, for which see problem 13. of Spheric Trigonometry Geometrical, in page 126, and chapter 5. section 4. problem 4. cases 10 and 12. of Spheric Trigonometry Rectangular, in pages 128 and 129. For the proportions.

Problem 12. The latitude of a place, and the sun's declination given; to find his altitude, and azimuth at the hour of six.

Definition 1. Altitude is an arch of an azimuth circle contained between the horizon and any parallel of altitude; as b f. Plate 7. fig. 2.

2. Azimuth, is an arch of the horizon, contained between the meridian of the place, and any azimuth circle. Or contained between the prime vertical and any other azimuth circle; as Ab. Plate 7. fig. 2.

Example. The { latitude— — ——51d. 32m.
sun's declination——23d. 30m. } north

Note; At six of the clock the sun is upon the axis PAI.

In the rectangle spheric triangle Abf (plate 7. fig. 2.) is to be noted.

1. Ab

1. A b f the rectangle.
2. b A f the latitude of the place.
3. A f the sun's declination, of the same name with the lat.
4. b f the sun's altitude at the hour of 6.
5. A b the sun's azimuth from the east at six in the morning, and from the west at six afternoon: northerly in north latitudes, but southerly in south latitudes.

To project it stereographically on the plain of the meridian.

1. Having described the primitive circle, quartered it, drawn the axis of the world PAI, the equinoctial ÆQ, and the parallel of declination ♋ ☉ I f R g; as before directed in problem 4. of this chapter, in pages 199 and 200.

2. Through f (where the parallel of declination cutteth the axis PAI) draw an oblique circle perpendicular to the horizon SAB (by problem 5. case 3. of Spheric Geometry, in pages 106 and 107.) as is the azimuth circle Z f b N. to cut SAB in b, which form the rectangle triangle A b f and it's done.

For the leg A b, the sun's azimuth, and the leg b f the sun's altitude at six of the clock, are the two things required, and are measured by problem 7. cases 2 and 3. of Spheric Geometry, in pages 109 and 110.

But by Spheric Trigonometry, having the hypotenuse and one angle given, that is A f, 23d. 30m. the sun's declination, and b A f 51d. 32m. the latitude; the leg b f the sun's altitude, and leg A b his azimuth at six of the clock; and found by chapter 5. section 4. problem 2. case 4 and 5. of Spheric Trigonometry Rectangular, in pages 126 and 127.

1. To find the sun's altitude at six, the proportion is;

As the radius, is to the sine of the latitude; so is the sine of the sun's declination, to the sine of the sun's altitude, at the hour of six. Or thus;

As radius. ·· S. angle bAf :: S. hypot. Af. ·· S. leg bf.
As S. 90d. ·· S. 51d. 32m. :: S. 23d. 30m. ·· S. 18d. 12m.

2. To find the sun's azimuth, the proportion by the aforesaid problem is;

As the radius, is to the sine complement of the latitude; so is the tangent of the sun's declination, to the tangent of the sun's azimuth from the east or west, at the hour of six. Or thus;

As radius ·· S. c. angle bAf :: T. hypot. Af ·· T. leg Ab.
As S. 90d. ·· S. 38d. 28m. :: T. 23d: 30m. ·· T. 15d. 08m.

That is;

At six in the morning the sun is E. 15d. 08m. N. or near upon the ENE ¼ E. point of the compass. And at six afternoon he is nearly upon the WNW ¼ W. Point of the compass.

In the same triangle A b f (plate 7. fig. 2.) may be resolved the five problems next following; to exercise the young learner.

Problem

Problem 13. The latitude and sun's altitude at the hour of six given; to find his declination and azimuth.

Example. The { latitude — — — 35d. 20m. south.
sun's altitude — — 9d. 50m. P.M.

Here is one leg and its opposite angle given; that is, the leg b f 9d. 50m. the sun's altitude, and the angle b A f, 35d. 20m. the latitude; which triangle is made by problem 13. of Spheric Trigonometry Geometrical in page 126; and for its solution, see chapter 5. section 4. problem 4. cases 10 and 12. in pages 128 and 129. And it's thus;

1 For the sun's declination, the proportion is;
As S. latitude ·· radius :: S. ⊙ alt. at 6. ·· S. ⊙ declin. requi.
As S. 35d. 20m. ·· S. 90d. :: S. 9d. 50m. ·· S. 17d. 10m. south.

2. For the sun's azimuth at 6, the proportion is;
As radius ·· Tc. latitude :: T. ⊙ alt. at 6. ·· ⊙'s azim. req.
As T. 45d. ·· T. 54d. 40m. :: T. 9d. 50m. ·· S. 14d. 9m. W. Southerly, or WSW. ¾ W. is the point of the compass the sun is upon.

Problem 14. Latitude, and sun's azimuth at the hour of six given; to find his declination, and altitude.

Example. The { latitude — —36d. 19m. north.
sun's azimuth— 10d. 14m. W. northerly.

Here is a leg and its adjacent angle given; that is, the leg Ab 10d. 14m. the sun's azimuth, and the angle b A f 36d. 19m. the latitude; which triangle is made by problem 12. of Spheric Trigonometry Geometrical, in page 115; and for its solution, see chapter 5. section 4. problem 3. cases 7 and 9. in pages 127 and 128. Which is thus;

1. For the sun's declination, the proportion is;
As T. ⊙ azim. ·· radius :: S. c. latitude ·· T. c. ⊙ declin. Or,
As S. c. latitude ·· radius :: T. ⊙ azimuth ·· T. declination
As S. 53d. 41m. ·· S. 90d. :: T. 10d. 14m. ·· T. 12d. 38m. N.

2. For the sun's altitude at 6, the proportion is;
As Tc. latitude ·· radius :: S. ⊙ azim. ·· T. ⊙ altitude, Or,
As radius ·· S. azimuth :: T. latitude ·· T. ⊙ alt. at 6.
As S. 90d. ·· S. 10d. 14m. :: T. 36d. 19m. ·· T. 7d. 26m. alt. at 6.

Problem 15. The sun's declination and altitude at the hour of six given; to find the latitude, and his azimuth.

Example. Sun's { declination — — 21d. 30m. south.
altitude — — —15d. 56m. A.M.

Here is the hypotenuse and one leg given; that is, Af 21d. 30m the sun's declination, and bf, 15d. 56m. the ⊙'s altitude, for

for which see problem 10. of Spheric Trigonometry Geometrical, in page 113. and chapter 5. section 4. problem 1. case 2 and 3. of Spheric Trigonometry Rectangular, in pages 125 and 126.

Problem 16. Sun's declination and his azimuth at the hour of six given; to find the latitude and his altitude.

Example. Sun's { declination —19d. 24m. south. / azimuth — 10d. 09m. E. southerly.

Here is (as in the last problem) the hypotenuse and one leg given; that is, At 19d. 24m. the sun's declination, and Ab 10d. 09m. the ☉'s azimuth; for which see problem 10. of Spheric Trigonometry Geometrical, in page 113. and chapter 5. section 4. problem 1. case 1 and 3. of Spheric Trigonometry Rectangular, in pages 125 and 126.

Problem 17. Sun's azimuth and altitude at the hour of six given; to find the latitude and his declination.

Example. Sun's { azimuth — 16d. 10m. W. southerly. / altitude — 9d. 00m.

Here are both legs given; for which see problem 14. of Spheric Trigonometry Geometrical, in page 127. and chapter 5. section 4. problem 5. case 13 and 14. of Spheric Trigonometry Rectangular, in pages 129 and 130.

Problem 18. The latitude of a place, and the sun's declination given; to find the sun's altitude and the hour of the day when the sun is east or west.

Note, When the sun is either east or west, he is then upon the prime vertical ZAN, in plate 7. fig. 2.

Example. The { latitude — —51d. 32m. / sun's declination 23d. 30m. } north

In the Rectangle Spheric Triangle Akl. plate 7. fig. 2. Observe That,

1. Akl the rectangle.
2. kAl the latitude.
3. kl the sun's decl. of the same name with the lat.
4. Al his altitude when he is upon the east or west azimuth circle
5. Ak the hour from 6; if east, after 6 in the forenoon; but when west, before 6 afternoon.

To project it Stereographically, on the plain of the meridian.

1. The primitive circle being drawn, quartered, as also the axis P A I, equinoctial ÆAQ, and parallel of declination ♋ ☉ If Rg, as formerly in problem 4. of this chapter, to cut the prime

prime vertical ZAN in I, the place of the sun when he is either east or west.

Then thro' I, draw a great circle to cut the equinoctial ÆA Q in k, at right angles by problem 5. case 3. of Spheric Geometry, in page 115, as the oblique circle PlkI, which forms the rectangle spheric triangle Akl.

For the hypotenuse Al. and leg Ak, the former the sun's altitude, the latter the hour from 6, when he is either east or west, are the two things required, and are measured by Problem 7. case 2. of Spheric Geometry, in pages 117 and 118.

But by Trigonometry, having a leg and its opposite angle given; that is kAl 51d. 32m. the latitude, and kl, 23d. 30m. the sun's declination: the leg Ak the hour from 6, and the hypotenuse Al the sun's altitude when east, or west; are found by chapter 5. section 4. problem 4. cases 10 and 12 of Spheric Trigonometry, in pages 128 and 129. Thus,

1. To find the sun's altitude, the proportion is;

As the sine of the latitude, is to the radius;

So is the sine of the sun's declination, to the sine of his altitude, being east or west. Or thus;

As S. angle KAI ·· radius :: S. leg kl ·· S. hypot. Al.

As S. 51d. 32m. ·· S. 90d. :: S. 23d. 30m. ·· S. 30d. 37m. ☉ alt.

2. To find the hour from 6, the proportion by the aforesaid problem 4. and case 10. is;

As the radius, is to the tangent of the complement of the latitude;

So is the tangent of the sun's declination, to the sine of the hour from 6. Or thus,

As radius ·· Tc. angle kal :: T. leg kl. ·· S. leg Ak.

As T 45d. T.··38d. 28m.:: T. 23d. 30m.··S. 20d. 13m. the hour from six.

Which reduce into hours and minutes of time, and add it to, and subtract it from 6 hours, giveth the hour of the day required.

That is, 20d. 13m. reduced into time is 1h. 21m. almost

Which added to ———— ——— ———— 6h. 00m.

The sum sheweth the sun is east at ——— 7h. 21m. morn.

And being subtr. sheweth the sun is west 4h. 37m. aftern.

In the same rectangle spheric triangle Akl, (plate 7. fig. 2.) the five problems following may be resolved, to exercise the learner.

Problem 19. The Sun east, the Latitude, and the Sun's Altitude given; to find the Declination, and the hour of the day.

Example. The { latitude ——— 51d. 30m. north.
sun's altitude, 25d. 16m. morning. Here

Here is the hypotenuse, and one angle given; that is the hypotenuse Al. 25d. 16m. the Sun's Altitude, and the angle k Al. 51d. 30m. the latitude; which triangle is made by problem 11. of Spheric Trigonometry Geometrical, in page 115. and for its resolution, see chapter 5. section 4. problem 2. cases 4 and 5. in pages 126 and 127. And is thus.

1. For the sun's declination, the proportion is,

As radius -- S. latitude :: S. ⊙ altitude -- S. ⊙ declinat. req.
As S. 90d. -- S. 51d. 30m. :: S. 25d. 16m. -- S. 19d. 30m. nor.

2. For the hour when he is East, it's thus;

As T. c. ⊙ alt. -- rad. :: S. c. lat. -- T. hour from 6 when E. Or,
As radius -- S. c. lat. :: T. ⊙ alt. -- T. hour from 6 when E.
As S. 90 -- 38d. 30m. :: T. 25d. 16m. -- T. 16d. 20m. or 1h. 5m.
which added to 6, makes 7h. 5m. the time when the sun is east.

Problem 20. The sun west, the latitude and hour of the day given; to find his altitude, and declination.

Example. The { latitude 30d. 10m. south.
{ hour 3h. 15m. Pm. or afternoon.

Here is given a leg, and it's adjacent angle; that is; the leg Ak 41d. 15m. or 2h. 45m. the hour from 6, when the sun is west; and the angle kAl 30d. 10m. the latitude; which triangle is made by problem 12. of Spheric Trigonometry Geometrical. And for its resolution, see chapter 5. section 4. prob. 3. case 7, and 9. in pages 127 and 128. And it's thus.

1. For the sun's declination, the proportion is,

As T. c. lat. -- radius :: S. hour from 6 -- T. ⊙ declina. Or,
As radius -- S. hour from 6 :: T. latitude -- T. ⊙ decli. req.
As S. 90d. -- S. 41d. 15m. :: T. 30d. 10m. -- T. 20d. 58m. south.

2. For his altitude, the proportion is,

As T. hour from 6. -- radius :: Sc. lat. -- Tc. ⊙ alt. when W. Or,
As S. c. lat. -- radius :: T. hour from 6. T. -- ⊙ alt. when W. req.
As S. 59d. 50m. -- S. 90d. :: T. 41d. 15m. -- T. 45d. 23m ⊙ alt. when west.

Problem 21. The sun east, his declination, and altitude given; to find the latitude and hour of the day.

Example. The sun's { declination 20d. 50m. south.
{ altitude 29d. 30m. A.M. or morn.

Here are given the hypotenuse, and one leg; that is, the hypotenuse A l, 29d. 30m. the Sun's Altitude, and the leg k l 20d. 50m. his Declination: which triangle is made by problem 10. of Spheric Trigonometry Geometrical in page 122. and for its resolution, see chapter 5. section 4. problem 1. cases 2 and 3, in pages 125 and 126. Problem

Problem 22. *The sun west, his Declination, and hour of the day given, to find the Latitude, and his Altitude.*

Ex. The { *Sun's declination* 10d. 39m. *north.*
Hour of the day 4h. 52m. *P. M. (or Afternoon.)*

Here are given both legs; that is, the leg k l 10d. 39m. the Sun's Declination, and leg A k 17d. or 1h. 8m. the Hour from 6, when the sun is west; for making this triangle, see problem 14 of Spheric Trigonometry Geometrical, in page 127. And for its resolution see chapter 5. section 4. problem 5. cases 13 and 14. in pages 129 and 130.

Problem 23. *The Sun east, his Altitude, and the hour of the day given; to find the Latitude, and his Declination.*

Example. The { *Sun's altitude* — —30d. 10m.
Hour of the day — -7h.- 50m.

Note, In this problem the Latitude may be either north or south, and truly answer the question.

Here is given the hypotenuse, and one leg; that is the hypotenuse A l 30d. 10m. the Sun's Altitude when east, and the leg A k 27d. 30m. or 1h. 50m. the hour from 6, when he is so; this triangle is made by problem 10. of Spheric Trigonometry Geometrical, in page 114, and for its resolution, see chapter 5. section 4. problem 1. cases 1 and 3. in pages 125 and 126.

Problem 24. *The sun in the Equinoctial, the Latitude of a place and the Sun's Altitude given; to find his Azimuth, and the hour of the day.*

Note, When the Sun hath no declination, he is then (said to be) in the Equinoctial; which is twice in a year about the 10th of March, and the 12th of September.

Example. The { *Latitude* 51d. 32m. *north*
Sun's altitude 21d. 50m. *AM (or morning.)*

In the Rectangle Spheric Triangle ZÆD. Plate 7. fig. 2. it is to be noted.

1. ZÆD the Rectangle.
2. ZE the latitude of the place.
3. ÆD the hour of the day from noon.
4. ZD the complement of the sun's altitude.
5. ÆZD the sun's azimuth from the South in North Latitude; but from the North in South Latitude, easterly in the forenoon, and westerly in the afternoon.

To project it Stereographically, by the plain scale.

1. The primitive circle being drawn, quartered, as also the axis PAI, and equinoctial ÆAQ, as formerly directed in problem 4.

2. By problem 9. case 2. of Spherical Geometry, in page 112. draw a parallel circle at 21d. 50m. (the given Altitude) distance from the horizon SAB; as is ADIt to cut the Equinoctial ÆAQ in D; the place of the sun at that time.

3. Through D (by problem 5. case 3. of Spherical Geometry, in page 107.) draw a great circle perpendicular to SAB, as is the oblique circle ZDCN, which concludes the rectangle spheric triangle ZÆD, and it's done.

For the angle ÆZD and leg ÆD; the former the Sun's Azimuth from the meridian, the latter the hour from noon, when the sun is in the equinoctial, are the two things required, and are measured by problem 7. case 2. and problem 8. case 2. of Spherical Geometry, in pages 110 and 111.

But by spheric trigonometry, having the Hypotenuse, and one Leg given; that is ZD 78d. 10m. the complement of the Sun's Altitude, and ZÆ 51d. 32m. the latitude: the angle ÆZD the sun's azimuth and leg ÆD the hour from noon, are found by chapter 5. section 4. case 1 and 2. of Spheric Trigonometry Rectangular, in pages 125, 126. Thus,

1. To find the Sun's Azimuth, the proportion is.

As the radius is to the tangent of the latitude;

So is the tangent of the sun's altitude, to the sine complement of the sun's azimuth from the south. Or thus;

As radius ·· T. leg ZÆ :: T. c. hypot. ZD ·· Sc. angle ÆZD.

As T. 45d. ·· T. 51d. 32m. :: T. 21d. 50m. ·· S. 30d. 17m.

Which subtract from — — — 90d. 00m.

Remainder is the Sun's Azimuth, south — 59d. 43m. easterly, that is SE. by E. $\frac{1}{4}$E. is the point of the compass the sun is upon.

1. To find the hour, the proportion by the foresaid problem 2. and case 3. is;

As the sine complement of the latitude, is to the radius;

So is the sine of the sun's altitude, to the sine complement of the hour from noon. Or thus;

As S. c. leg ZE ·· radius :: S. c. hypot. ZD. ·· S. c. leg ÆD.

As S. 38d. 28m. ·· S. 90d. :: S. 21d. 50m. ·· S. 36d. 43m.

Which subtract from — — —90d. 00m.

Remainder is the hour from noon — —53d. 17m.

Which is equal to 3h. 33m. from noon, that is 8h. 27m. in the Morning.

In

In the same rectangle spheric triangle ZÆC might five problems more be resolved, which I leave to the learner to invent, and so pass on to Oblique Spheric Triangles in Astronomy.

Section III. *Oblique Spheric Triangles, applied in Astronomical Problems, useful in Navigation.*

IN the last Section, rectangled spheric triangles were applied to Problems of Astronomy, now in like manner oblique spheric triangles shall be applied, and both them and the following are useful in Navigation.

Problem 1. *The Latitude of a place, the Sun's Declination, and his Altitude given; to find his Azimuth, and the hour of the day.*

Example. The { Latitude —51d. 30m. / Declination—15. 10 / Altitude —11. 30 } north.

In the oblique spheric triangle PZ⊙. Plate 7. figure 2. is to be noted.

1. ZP the complement of the latitude.
2. Z⊙ the complement of the sun's altitude.
3. Z⊙ his distance from the elevated pole; which is the declination added to 90 degrees, when the latitude and declination are of the contrary names; but if of one name, it's the complement of the declination.
4. PZ⊙ his azimuth from the north in north latitude; but from the south in south latitude.
5. ZP⊙ the hour of the day from noon.

To project it Stereographically on the plain of the meridian.

1. Having drawn the primitive circle and quartered it, also drawn the axis PAI, the equinoctial ÆAQ, draw the parallel of declination ⊙ I f R g, as before directed.
2. Draw (by problem 9. case 2. of Spheric Geometry in page 112) a parallel circle, parallel to the Horizon SAB at 11d. 30m. (the given altitude) distance from it, to cut the parallel of declination in ⊙, the place of the sun at that time.
3. Then through ⊙ draw two great circles, one through Z and N, the poles of the Horizon; and the other through P and I the poles of the equinoctial; as is the Oblique Circle, ZON, and POI; which forms the Oblique Spheric Triangle PZ⊙, and it's done.

For the angles PZ⊙, and ZP⊙, the fo[illegible] the sun's azimuth, the latter the hour of the d[illegible] noon; [illegible] things required, and are m[illegible] by problem 8. case 2. of Spheric Geometry, [illegible] page 110.

But by sph[illegible] trigonometry, having 3 sides given; that is ZP. 38[illegible] 30m. the complement of the latitude, Z⊙, 78d. 30m.

 the

the complement of the Sun's Altitude; and P⊙, 74d. 50m. his diſtance from the elevated pole; the angle PZ⊙ the Sun's Azimuth, and ZP⊙ the Hour of the Day; are found by chapter 5. ſection 5. problem 11. caſe 11. of Spheric Trigonometry Oblique, in pages 136 and 137. as followeth.

1. Add the complement of the latitude, complement of the Sun's altitude, and the Sun's diſtance from the pole into one ſum.

2. From half that ſum ſubtract, for finding the ſun's Azimuth, the ſun's diſtance from the pole: but, for finding the hour of the day, ſubtract the complement of the ſun's altitude, noting the half ſum, and the remainder.

3. Then to find the ſun's azimuth, it's thus; to the Complement Arithmetical of the ſines of the complement of the latitude and complement of the altitude, add the ſines of the foreſaid half-ſum and remainder: half the total of theſe 4 logarithims, is the ſine of the Supplement of half the ſun's azimuth from the north in north latitude; and from the ſouth in ſouth latitude.

But to find the hour of the day, it's thus; to the Complement Arithmetical of the ſines of the complement of the latitude, and the ſun's diſtance from the pole, add the ſines of the ſaid half-ſum, and the remainder: half the total of theſe 4 logarithms, is the ſine of the ſupplement of half the hour from noon, ll which is ſhortned thus;

1. To find the azimuth, the operation is;

Side ZP.	38. 30m.	containg ſides	S. co. ar. 0.205850
Side Z⊙.	78. 30m.	containg ſides	S. co. ar. 0.008107
Side P⊙.	74d. 50m.	half ſum ſides 95d. 55m.	S. 9.997680
Sum is	191d. 50m.	Remainder — 21d. 05m.	S. 9.555971
½ Sum is	95d. 55m.	Sum of the 4 logarithms is	19.708308
Remaind.	21d. 05m.	49 59 S. ½ ſum	9.884154

Which doubled — 49 59

The double is — — 99 58 Which
Subtract from —— 180 00

Remainder is the ſun's azimuth 80 02 from the north.

O... by Gunter's ſcale.

As the radius ·· S. c. latitude :: S. c. a... ...de :: a 4th ſine
As S. 90d. ·· S. 38d. 30m. :: S. 78d. 30m. :: S. ...d. 35m.

Then

Then again,

As the 4th sine .. S. ½ sum sides :: S. remainder .. a 5th sine

As S. 37d. 35m. .. S. 95d. 55m. :: S. 21d. 05m. .. S. 36d. 06m.

Against which, on the line of versed sines is 80d. 02m. the sun's azimuth from the north easterly, if in the morning, and from the north westerly if in the afternoon; that is, the sun is near the east by north point of the compass in the morning and near the west by north point in the afternoon.

2. To find the hour of the day, the operation is,

Side { ZP 38d. 30m. } containing sides { S. co. ar.- 0.205850
Side { ⊙P 74d. 50m. } containing sides { S. co. ar.- 0.015397
Side { Z⊙ 78d. 30m. half sum sides 95d. 55m. S. -- 9.997680
Remainder 17d. 25m. S. -- 9.476133

Sum is 191d. 50m.

Sum of the 4 logarithms is-19.695060

½ sum is 95d. 55m.

Remainder 17d. 25m. ——44. 45 S. half sum 9.847530

Which doubled——44. 45

The double is --- 89. 30 Which
subtract from --- 180 00

	h. m.
rem. is the hour from noon 90. 30 equal to	6. 02

Or thus; by Gunter's scale.

As the radius .. sec. latitude. :: S. ⊙ dist. from pole .. a 4th sine

As S. 90d. .. S. 38d. 30m. :: S, 74d. 50m. .. S. 36d. 56m.

Then again,

As the 4th sine .. S. ½ sum sides :: S. remainder .. a 5th sine.

As S. 36d. 56m. .. S. 95d. 55m. :: S. 17d. 25m. .. 29d. 42m.

Against which on the line of versed sines, is 90d. 30m.

Or 6h. 2m. the hour from noon; that is, 58m. after 5 in the morning, or 2m. after 6 in the afternoon.

In the same spheric triangle ZP⊙ (Plate 7. fig. 2.) may the nine problems next following be resolved.

Problem 2. *The Latitude of a place, the sun's Altitude, and Azimuth given; to find his Declination, and the hour of the day.*

Example. *The* { latitude——51d. 32m. north.
{ sun's altitude-49d. 40m. in the forenoon.
{ sun's azimuth 119d. 44m. from the north.

In this problem are two sides, and one angle between them given; that is, ZP 38d. 28m. the complement of the Latitude, Z⊙ 40d. 20m. the complement of the Sun's Altitude, and PZ⊙ 119d. 44m. his azimuth; which triangle is made by prob. 18. of Spheric Geometry; and for its resolution, see chapter 5. section 5. problem 9. case 7 and 8. of Spherical Trigonometry Oblique, pages 133 and 134.

Problem 3. *The Latitude, the Sun's Declination and Azimuth given; to find his Altitude, and the hour of the day.*

Ex. The { latitude ———— 13d. 10m. north. / ⊙ declination ——— 79d. 15m. south. / ⊙ azimuth ——— 129d. 40m. from N aftern.

Here are two sides and one angle opposite given, that is ZP 76d. 50m. the complement of the latitude, P⊙ 99d. 15m. the sun's distance from the elevated pole, and PZ⊙ 129d. 40m. his azimuth; which triangle is made by problem 16 of Spheric Geometry, in pages 118 and 119. And for it's solving, see chapter 5. section. 5. problem 7. cases 2 and 3. of Spheric Trigonometry Oblique, in pages 131 and 132.

Problem 4. *The Latitude of a place, Sun's Altitude, and the hour of the day given; to find the Sun's Azimuth, and his Declination.*

Example. The { latitude ———— 30d. 51m. south. / altitude ———— 41d. 10m. / hour of the day — 3h. 15m. afternoon.

Here are two sides, and one angle opposite given as before in problem 3. That is, ZP 59d. 09m. the complement of the latitude Z⊙ 48d. 50m. the complement of the Sun's Altitude, and ZP⊙ 48d. 45m. or 3h. 15m. the hour of the day from noon; and therefore projected, and resolved like problem 3. aforesaid, in page 213.

Problem 5. *The Latitude of a Place, the Sun's Declination, and hour of the day given; to find the Azimuth, and Altitude.*

Exmpale. The { latitude ———— 20d. 11m. north. / declination ——— 23d. 29m. south. / hour ———— 9h. 24m. morning.

Here are two sides, and one angle between them given; that is, ZP 69d. 49m. the complement of the latitude, P⊙ 113d. 29m. the Sun's distance from the elevated pole, and PZ⊙ 39d. or 2h. 36m. the hour of the day from noon, which is wrought as before in problem 2. page 213.

Problem 6. *Latitude of a Place, the Sun's Azimuth, and the hour of the day given; to find the Declination and Altitude.*

Example. The { latitude ———— 13d. 10m. north. / sun's azimuth — 120d. 30m. from the north. / hour of the day - 9h. 36m. morning.

Here are two angles, and one side between them given; that is, ZP 76d. 50m. the complement of the Latitude, PZ☉ 120d. 30m. the Sun's Azimuth, and ZP☉ 36d. or 2h. 24m. the hour of the day from noon; for the making of this triangle, see problem 19. of Spheric Geometry, in page 120. And for its solution, see chapter 5. section 5. problem 10. case 9. of Spheric Trigonometry Oblique, in page 135.

Problem 7. *The Sun's Altitude, Declination, and his Azimuth given; to find the Latitude and hour of the day.*

Example. The sun's { altitude----39d. 30m. in the morning. declination 19d. 12m. north. azimuth -110d. 20m. from the north. }

Here are two sides, and one angle opposite given; that is, Z☉ 50d. 30m. the complement of the sun's altitude P☉ 70d. 48m. his distance from the elevated pole, and PZ☉ 110d. 20m. his azimuth from the north, which triangle is made and wrought as before in problem 3. of this section in page 222.

Problem 8. *The Sun's Altitude, his Declination, and hour of the day given; to find his Azimuth and the Latitude.*

Example. The { sun's altitude——12d. 35m. sun's declination- 19d. 40m. north. hour— — — 5h. 42m. morning. }

Here are also two sides, and one angle opposite given; that is, Z☉ 58d. 35m. the complement of the Sun's Altitude P☉ 70d. 20m. his distance from the elevated pole, and ZP☉ 94d. 30m. or 6h. 18m. the hour of the day from noon; which triangle is made and wrought as before in problem 3. of this section, in page 215.

Problem 9. *The Sun's Altitude, his Azimuth, and the hour of the day given; to find the Declination, and the latitude of the place.*

Example. The { sun's altitude ——11d. 30m. sun's azimuth——75d. 00m. from the N. hour of the day—06h. 16m. afternoon. }

Here are two angles and one side opposite given; that is, Z☉ 78d. 30m. the complement of the sun's altitude, PZ☉ 75d. The sun's azimuth from the north, and ZP☉ 94d. 00m. or 6h. 16m. the hour from noon; which triangle is made by problem 17 of Spheric Geometry, and is solved by chapter 5. section 5. Problem 8. case 4 and 5. of Spheric Trigonometry Oblique, in Pages 133 and 134.

Problem 10. *The Sun's Declination, his Azimuth, and hour of the day given; to find his Altitude and the latitude of the Place.*

Example. { sun's declination —— 19d. 10m. north. sun's azimuth —— 79d. 02m. from the S. hour of the day—— 08h. 32m. in the morning. }

Here are two angles and one side opposite given; as before in the last Problem: that is, P☉ 70d. 50m. the sun's distance from the elevated pole, PZ☉ 109d. 58m. his azimuth from the north, and PZ☉ 52d. Or 3h. 28m. the hour of the day from noon; which triangle is made and wrought like Problem 9. the last foregoing.

Problem 11. *The Latitude and Longitude of a Star, and the Obliquity of the Ecliptic given; to find his Right Ascension and Declination.*

Definition 1. Latitude of a star, is an arch of a circle of longitude contained between the star's center, and the ecliptic.

2. Longitude of a star, is an arch of the ecliptic, contained between the beginning of Aries, and that circle of longitude, which passeth over the star's center, and counted according to the succession of the signs.

Example.

Capella, or the Goat, the { latitude —— 22d. 52m. north. longitude ♊. 18d. 02m. }

In the oblique spheric triangle PKD, plate 7. fig. 1. is to be noted.

1. PK the distance of the pole of the ecliptic from the pole of the world, equal to the ecliptic's obliquity 23d. 30m.

2. KD the star's complement of latitude, or distance from one pole of the ecliptic.

3. PD the complement of the star's declination, or distance from the agreeing pole of the world.

4. PKD it's longitude from ♋, if the star's latitude be north, but from ♑ if it be south; that is, from ♋, if the ecliptic's north pole be one angle; but from ♑ if its south pole be one angle of the triangle.

5. KPD the star's right ascension from ♑, if its latitude be north, but from ♋ if its latitude be south: that is, if the ecliptic's north pole be one angle, &c. as before in the 4th Sept.

Here are two sides, and one angle between them given; that is, PK 23d. 30m. the distance of the north poles of the equinoctial, and ecliptic, KD 67d. 08m. the complement of the star's latitude, and PKD 11d. 58m. the star's longitude from (wanting of) ♒; which triangle is made by Problem 18 of Spherical

Geometry, in pages 119 and 120. and by chapter 5. section 5. problem 9. case 7 and 8. in pages 104 and 105. the proportions are as follows:

First, To find the star's right ascension, the Operation is

1. As S. half sum of the sides KD and CP. — —45d. 19m.
Is to S. half their difference ———————————21d. 50m.
So is Tc. of half the angle PKD———————————84d. 01m.

To T. half diff. of the angles DPK and PDK 78d. 40m.

2. As S. c. half sum of the sides KD and KP———44d. 41m.
Is to S. c. half difference———————————68d. 10m.
So is Tc. of half the angel PKD——————————84d. 30m.

To T. half sum of the angles DPK and PDK———85d. 27m.
Unto which add their half diff. before found———78d. 40m.

And it giveth the angle DPK ———————————164d. 07m.
From which subtract AQ ——————————————90d. 00m.

Remainder is AM the star's right ascension———74d. 07m.
from the beginning of ♈ required.

Secondly, For the star's declination, the Operation is;
As S. DPK star's right ascension from ♑ — ——164d. 07m.
Is to S. DK its complement of latitude ———— 67d. 08m.
So is S. PKD its longitude from ♋ ——————11d. 58m.

To S. PD its complement of declination ——— 44d. 19m.

Wherefore the star's declination is north ——— 45d. 41m.

Problem 12. *The right ascension of the sun, and right ascension of a star given; to find the time of the star's coming to, or upon the meridian.*

The rule. Subtract the sun's right ascension from the star's right ascension, the remainder reduced into time, is the time of the star's coming upon, or to the meridian, afternoon.

Note, If you cannot subtract, add 360 degrees to the star's right ascension, and then subtract.

Example. *The 5th of October 1731, I demand at what time Aldebaran, or the Bull's Eye, cometh to the meridian?*

			d.	m.	
The	5th of October, the sun's declination is		8	53	S increase.
	latitude	of Aldebaran is	5	30	south.
	longitude		5	57	in ♊

And

And therefore you may find that,

					d.	m.
By ſect.	3. problem 11.	the	ſtar's	right aſc. is	65	03
	2. problem 3.		ſun's		200	45

Then add 360d. to 65d. 03m. the ſtar's right aſcenſion, and it is 425d. 03m. from which ſubtract 200d. 45m. the ſun's right aſcenſion, the remainder is 224d. 18m. which maketh 14h. 57m. the ſtar's coming to the meridian after noon, that is 57m. after two in the morning.

And thus having found the Right Aſcenſion, Declination and time of any ſtar's coming upon the meridian, you may by problem 4. ſection 2. of this chapter, find its amplitude, and aſcenſional difference, and thereby its riſing and ſetting: its diſtance from the meridian at any altitude, obſerved by problem 1. ſection 3. of this chapter, in page 212, and ſo the hour of the night thereby; all which I leave for the exerciſe of thoſe that are learning theſe things.

Section IV. *The doctrine of the Sphere, or Spheric Trigonometry, applied in ſundry Aſtronomical Problems, uſeful in Navigation, according to the Pythagorean Syſtem.*

THE Pythagorean Syſtem of the World, lately revived by Copernicus, is now generally received by the moſt, and beſt aſtronomers; it being indeed the moſt agreeable to the motion of the Heavenly Bodies, confirmed by experience in the conſtant obſervation of them, in which theſe are Fundamental Principles.

1. That the earth is carried round the ſun in a large orb or path, betwixt the orbs of the planets Mars and Venus, once in a year.

2. That beſides this Annual Motion, the earth turn's round her own axis once in 24 hours.

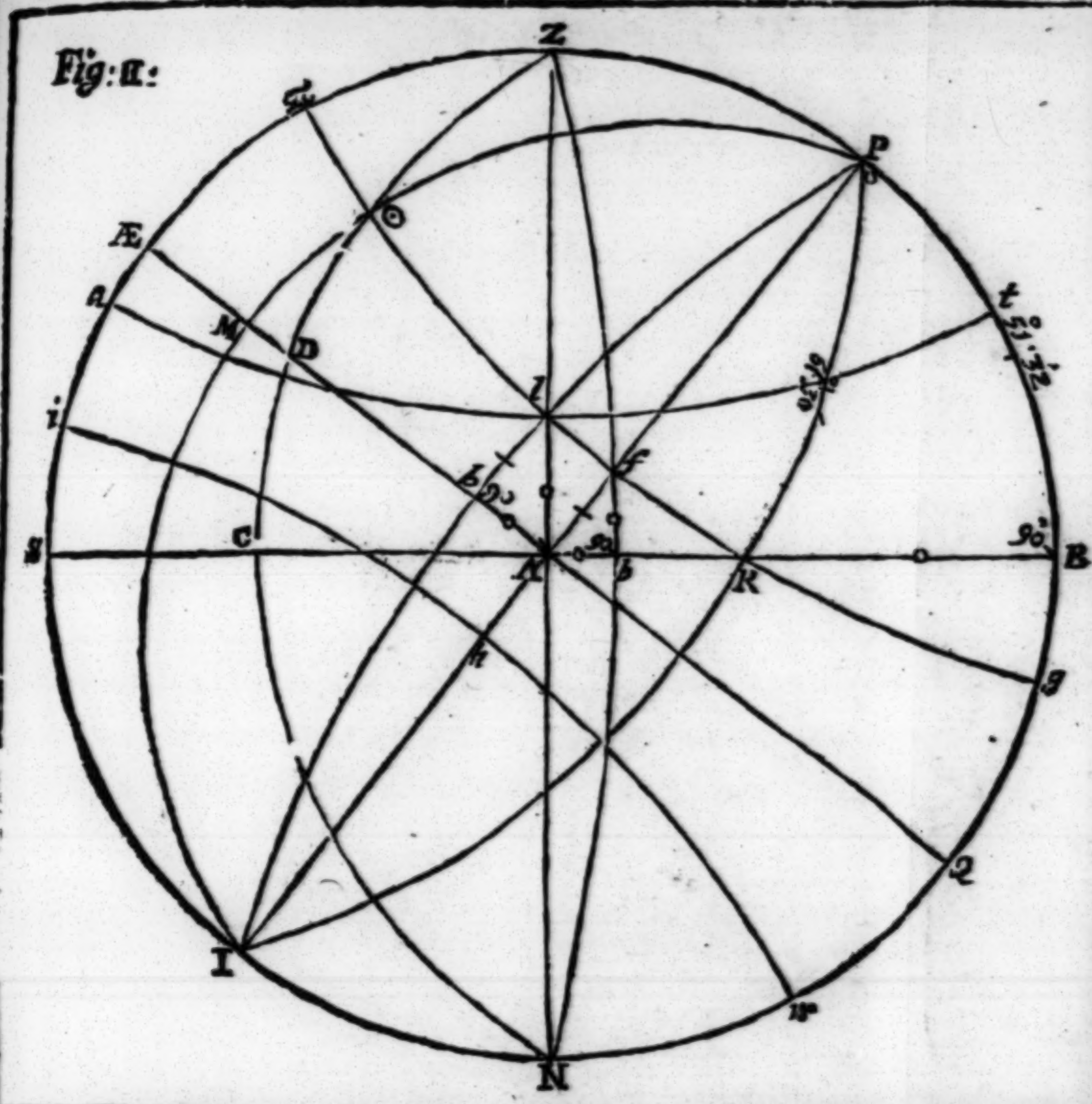
3. And that the ſaid axis of the earth is inclined to the plane of her orb at the ſame angle, and keeps in all parts of it, nearly parallel to itſelf.

On theſe aſſertions, but chiefly the ſecond; to wit, the Diurnal Motion of the Earth about its own Axis once in 24 hours, whereby all the viſible appearances of the ſun and fixed ſtars are ſolved, I ſhall at preſent confine my diſcourſe, and on which the following problems are grounded.

In order to a right underſtanding thereof, I will deſcribe the circles of the ſphere, and how they are drawn in the Stereographical Projection, on the plane of the Earth's Ecliptic, before I ſhew how to calculate any of its requiſites.

Note, In the following deſcription, I make uſe (for the moſt part) of the ſame letters for the ſame things, as before in the Ptolemaic Projection, treated of in this chapter.

The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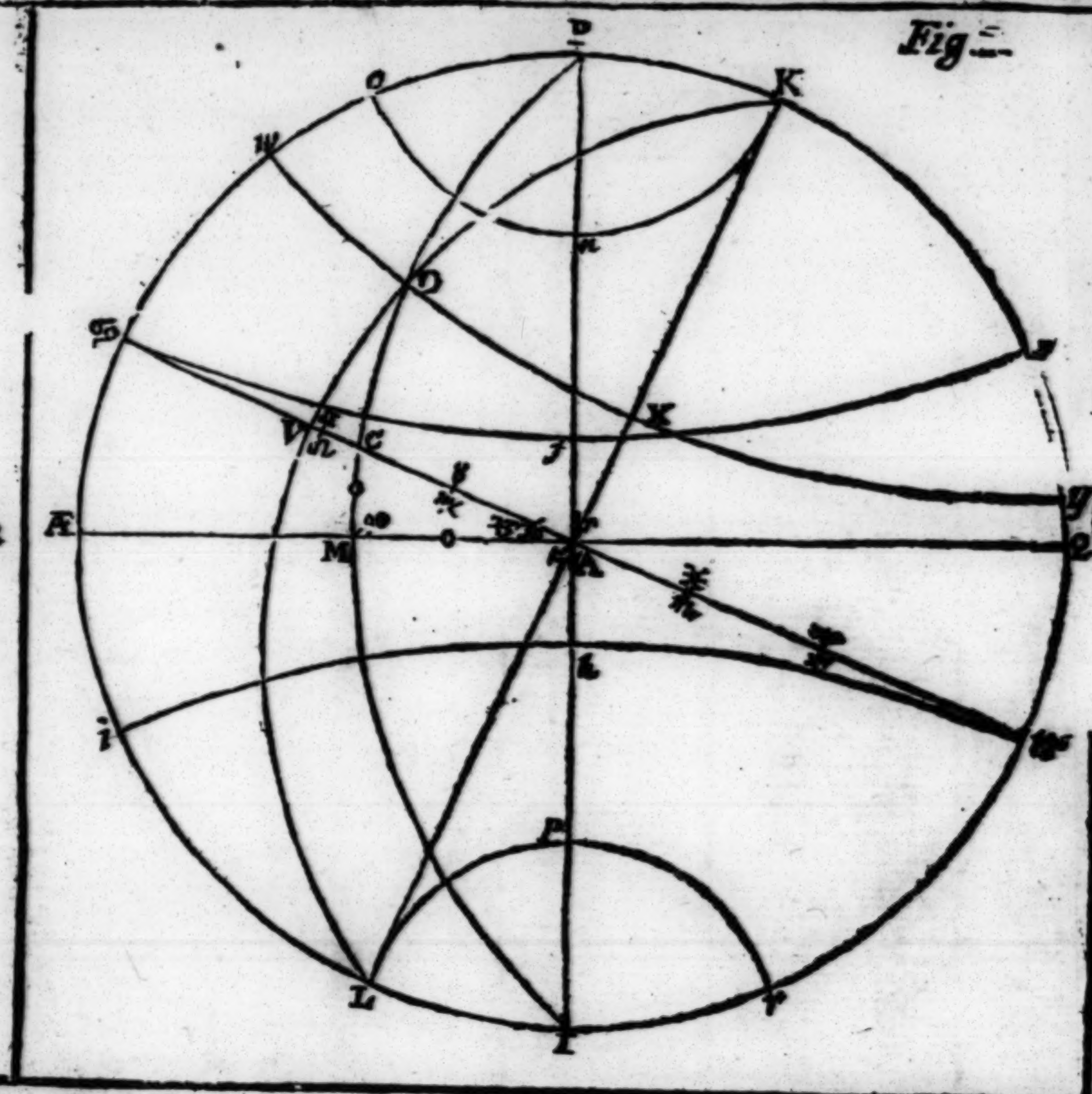
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The description if the circles of the Sphere (as grounded on the antient Pythagorean, or Copernican System of the World,) are as followeth.

1. The sun illuminateth one half of the body of the earth continually; as represented by plate 8. fig. 1 and 2. wherein the lines HKS, or HLS, which determineth the illuminated Part of the Earth's Disk A☉S, from the obscure HDS; the said HKS, or HLS, is called the horizon of the Earth's Disk.

2. The primitive circle ♈♋♎♑♈, is the earth's ecliptic; which ever lieth in the plane of the ecliptic in the heavens.

The poles of the ecliptic are K and L; the first is the north pole of the ecliptic, on the earth's globe, and the latter the south pole thereof.

The poles of the earth's globe are P and I; the first its north and the latter its south pole; each being 23d. 30m. from its correspondent pole of the ecliptic; that is KP, equal to LI, is equal to 23d. 30m. on the scale of Half-Tangents, and it's called the line of direction of the earth's axis.

3. The equinoctial in the heavens, or equator on the earth, is represented by the oblique circles ♈ Q ♎, or ♈ Æ ♎, of which P and I are the poles; and they are drawn with the Secant of 23d. 30m. according to problem 2. case 2. of Spherical Geometry, in pages 104 and 105.

4. All meridians pass through the poles of the earth's globe; as here ♈P♎, or ♈I♎, are Meridians, and drawn with the Secant of 66d. 30m. the complement of 23d. 30m. as before.

♈♎P, or ♈I♎, is called the first meridian; and the meridian ♋ P K ♑, or ♋ L I ♑ is the earth's Solstitial Colure: for whenever the direct rays of the sun run parallel to this meridian, and that is, when the sun appears from the earth, to be either in ♋ or ♑; then the Longest or Shortest Days are made in all places on the globe of the earth.

The earth's equinoctial colure, is ♈ K ♎ or ♈ L ♎, for whenever the central rays of the sun run parallel to it, the days and nights are equal in all places. Or according to the Ptolemaick System, the meridian ♈ P ♎ and ♈ I ♎, is the equinoctial colure, tho' here we call it the first meridian.

5. Circles of longitude, pass thro' the poles of the ecliptic, and in this projection, are right circles; therefore are strait lines; as ♈ K ♎, ♋ K ♑, ☉ K D, &c.

Where for the point of the earth's periphery, opposite to the sun, or to a star, or lying in a strait line produced from K, or L, thro' the center of the sun, or any star, is called sun's or star's place in the ecliptic.

These are the great circles belonging to this Projection. Now followeth,

The

The description of the parallels or lesser circles.

6. Parallels of declination, are here parallels to an oblique circle; the equinoctial ♈ Q ♎, and ♈ Æ ♎, being such.

The tropics are two parallels of declination, distant from the equinoctial 23d. 30m. or 66d. 30m. from each pole of the world; as ♋ f g f ♋, and ♑ h i h ♑; the first is the tropic of cancer, the latter is the tropic of capricorn.

These tropics are thus drawn; from the Scale of Half-Tangents lay on the Solstitial colure 47. (the double of 23d. 30m. from ♑ to g, or from ♋ to i. Or thus; lay the Half-Tangent of 43d.) the complement of 47d. from K to g. or from L to i: then the middle between ♋ and g; or between ♑ and i, is the center of these tropics.

The polar circles, are two parallels of declination, distant from the equinoctial 66d. 30m. or 23d. 30m. from each pole of the world: as K n o n K, and L p r p L; the first is the artic, and the other the antartic circle.

They are thus drawn, on the Solstitial Colure, lay the Half-Tangent of 47d. (the double of 23d. 30m.) from K to o, or from L to r; then the middle between K and o, or between L and r, is the center of those polar circles.

7. Parallels of latitude, with respect to the heavens, are in this Projection parallel to the Primitive Circle, which here is the ecliptic: as any circle drawn on K or L; as a center is a parallel of latitude.

All these circles are general, as belonging to this Projection without any regard to the latitude of any particular place, on the globe of the earth: the description of the meridians, or hour circles, azimuths and parallels of latitude; also how to draw them (these being peculiar to a particular latitude) you shall have in their proper place, as they come in use in the following problems.

Problem 1. *The sun's place in the ecliptic given; to find his distance from the north or south pole of the globe; his right ascension; and the angle which the meridian passing through it, makes with the ecliptic.*

Example. *The sun's place being in the beginning of ♊, or 60 degrees from the first point of ♈; I demand his distance from the pole,* &c.

1. To do this, lay the sun's longitude from ♈ to 60d. on the primitive circle, from ♈ to ☉.

2. Through ☉ and P. or ☉ and I, draw a great circle ☉PD, or ☉ ID, which is the proper meridian, to the place of the sun.

3. Then

3. Then, between the proper meridian, the ecliptic, and the solstitial colure, there is formed a rectangle spheric triangle, having its legs given; to find the hypotenuse, and two angles: that is,

In the rectangle spheric triangle P ♋ ☉, or I ♋ ☉. Plate 8. fig. 1 and 2.

1. The leg ♋ ☉, is the complement of the sun's longitude from ♈, or his distance from the equinoctial, 30d.

2. The ♋ P, or ♋ I, the distance of the pole of the globe from the ecliptic; or the complement of the distance of the pole's of the globe and the ecliptic 66d. 30m.

3. The hypotenuse P ☉, or I ☉, the sun's distance from the north or south pole of the globe.

4. The angle ♋ P ☉, or ♋ I ☉, the complement of the sun's right ascension, from the nearest equinoctial point.

5. The angle P ☉ ♋, or I ☉ ♋, the angle of the proper meridian with the ecliptic.

1. For the sun's distance from the pole, the proportion by chapter 5. section 4. problem 5. case 14. of Spherical Trigonometry Rectangular, in pages 129 and 130. is thus,

As radius ·· S.c. leg ♋ ☉ : : S. c. leg ♋ P .. S. c. hypotenuse P ☉.
As S. 90d. ·· S. 60 degrees :: S. 23d. 30m. . . S. 20d. 12m. the Reflection ; That is,

As the radius is to the sine of the Sun's Longitude from the equinoctial.

So is the sine of the two Poles Distance, to the sine complement of his distance, from the nearest Pole of the globe; or to the sine of PB or IB the reflection, which is equal to the Sun's Declination in the Ptolemaic System: in this case 20d. 12m. north.

2. For the Sun's Right Ascension, the Proportion is;
As radius ·· S. leg P ♋ :: T. c. leg ☉ ♋ ·· T. c. angle ♋ P ☉.
As S. 90d. ·· S. 66d. 30m. : : T. 60d. ·· T. 57d. 47d. 49m. ☉ R Right Asc. That is,

As the radius is to the sine complement of the two Poles Distance.

So is the tangent of the sun's longitude from the nearest equinox, to the tangent of his right ascension from the said equinox.

3. For the angle of the proper meridian with the ecliptic, the proportion is thus;
As radius ·· S. leg ♋ ☉ :: T.c. leg ♋ P. ·· T. c. angle P ☉ ♋
As S. 90d. ·· S. 30d. :: T. 23d. 30m. ·· T. 12d. 16m.
Which subtract from——————90d. 00m.
The remainder being——————77d. 44m. is the Angle of the meridian and the ecliptic

In the same triangle may problem 2 and 3 of section 2. of this chapter be resolved, which I pass over.

Problem

Problem. 2. *The latitude of a place on the globe of the earth, and the sun's place in the ecliptic given; to find his amplitude and ascensional difference, and consequently his rising and setting.*

Ex. The {latitude —51d. 32m. N. / sun's place 00d. 00m. in ♊} given sun's {amp. and ascen. diff.} required. Plate 8. fig. 1 and 2.

1. To do this, after you have done what was directed in Problem 1. then get the sum and difference of the latitude's complement and the distance of the two Poles, that is the sum and difference of 38d. 28m. and 23d. 30m. the first is 61d. 58m. and the latter is 14d. 58m.

2. Then make K t or L t. equal to the half-tangent of 61d. 58m. and also K m, or L m, equal to 14d. 58m. on the same scale.

3. The middle between m and t, is the center of the circle abc z t d e h m, which is the parallel of latitude for 51d. 32m. and in this projection, it's the line described by London as the earth turns round, and from thence is called the Path of the Vertex.

And if you conceive the Colures, all the Meridians, the Path of any Vertex, and indeed all the lines and circles that are or shall hereafter be described as a fixed Rete, close investing the Earth whilst she turns round within it, whose motion about its Axis being from West to East, then the sun is said to Rise, when the Vertex passeth that point in the Path where it cuts the Horizon of the Earth's Disk, which is here at *a*; to Culminate or on the Meridian where it crosseth the proper Meridian betwixt him and the Pole, which here is at z.; and to Set where the Vertex passeth the other intersection of the Path and Horizon as here at h.

4. Thro' *a*, and ⊙, draw a great circle, as also thro' *a*, and P, so have you two Triangles on the East side of the Meridian, to wit, ⊙ P *a*, and P B *a*; in like manner if you draw a great circle thro' P and h; and thro' ⊙ and h; they will form two triangles on the west, or descending side of the Meridian: but if any one of these four triangles may serve to answer the Problem, and therefore I take one Triangle at Sun-rising, which may suffice for setting; wherein observe,

In the right-angled triangle PB*a*, plate 8. figure 1.

1. The leg PB the reflection or that which is equal to the Sun's Declination, found by Problem 1. in Page 219, to be 20d. 12m. north.

2. The Hypotenuse P*a*, the Complement of the Latitude of the Place, or the distance of the Pole from the Vertex. in this example 38d. 28m.

3. The

3. The angle B*a*P the Amplitude, or the complement of the Sun's Azimuth from the North in North Latitude; and from the South in South Latitude; from the angle P*a*☉ is the Azimuth from the North at Sun Rising. and the angle P*a*P is its Complement, and therefore equal to the Amplitude.

4. The angle B P *a*, the hour from Midnight; that is, the time of his rising after, and setting before 12 at night.

1 For the angle B*a*P, the Sun's Amplitude; the proportion by chapter 5. section 4. problem 1. case 2. in page 125 and 126. is thus;

As the S. hypotenuse P*a* ·· radius :: S. leg BP :: S. angle BaP.
As the S. 38d. 28m. ·· S. 90d. :: S. 20d. 12m. ·· S. 33d. 43m.
That is,

As the sine complement of the latitude is to the radius; so is the sine of the reflection, to the sine of the sun's amplitude; 33d. 43m. from the east northerly, at sun's rising; and from the west northerly, at sun setting.

For the angle BP*a*, the complement of the ascensional difference, the proportion by the aforesaid problem 1. case 1. page 125, thus,

As the radius .. T.c.hypot. P*a* :: T. leg BP. ·· S. c. angle BP*a*.
As the T. 45d. .. T. 51d. 32m. : : T. 20d. 12m. S. · · 27d. 35m.
the sun's ascensional difference, which is 01h. 50m. before 6, his rising; and as much after 6, is the Sun's setting, because its North Latitude, and the sun is in a Northern-sign; but it's the contrary when one is North and the other South.

In this triangle may Problem 4, 5, 6, 7, 8, 9, 10, and 11, of Section 2. of this Chapter be solved.

Problem 3. *The same given as before in Problem 2. to find the sun's distance from the vertex, when due east and west, and the time from noon when he shall be so.* Plate 8. *figure* 1.

Example.

Latitude——51d. 32m. N	} given;	the {	sun's zenith distance.
Sun's place ♊00 00			time when he is east.

or west required.

1. To delineate this; after the proper meridian, and Path of the Vertex, or parallel of latitude is drawn, as before in Problem 1 and 2. Then thro' ☉ and D, draw a great circle, just to touch the Path of the Vertex, on either side of it, as the oblique circles ☉ cd. and ☉ dD.

2. Through P and c; or P and D; draw a great circle, to cut ☉ cd, or ☉ dD at right angles, in the place of the Vertex, when the sun shall appear due east or west: and then there is formed two triangles, Pc☉, and Pd☉; one when the sun is east, and the other when he is west; in each the same things are given and required. Therefore observe.

In

In the Rectangle Triangle, P c ☉. Plate 8. fig. 1.

1. The hypotenuse P☉ the Sun's Distance from the pole, found by Problem 1. to be 69d. 48m. the complement of the reflection.

2. The leg P. c. the distance of the Pole, from the Vertex or complement of the latitude, in this example 38d. 28m.

3. The leg ☉ c the Sun's Distance from the Vertex, or complement of his Altitude when East: and the same when West.

4. the angle ☉Pc, the Hour from Noon, when he is or shall appear to be east or west.

1. For the leg ☉ c. the Sun's zenith distance, the proportion by chapter 5. section 4. problem 1. case 3. in pages 125 and 126. is this.

As S. c. leg Pc. ·· radius :: S. c. hypot. ☉ P ·· S. c. leg ☉c.
As the S. 51° 32′ ·· S. 90d. :: S. 20d. 12m. ·· S. 26. 10. Sun's Altitude when east, and the same when west.

That is,

As the sine of the Latitude, is to Radius,
So is the sine of the Reflection, to the sine complement of the Sun's Zenith distance; or his distance from the Vertex in this case 63d. 50m.

2. For the angle ☉Pc, the Hour from Noon, the Proportion, or thus;

As radius ·· T. leg Pc :: Tc. hypot. ☉P ·· Sc. angle ☉Pc.
As T. 45d. ·· T. 38d. 28m. :: 20d. 12m. ·· S. 17d. 00m. or 1h. 8m.

That is;

As the Radius is to the Tangent Complement of the Latitude;
So is the tangent of the Reflection, to the Sine Complement of the hour from noon, when the sun is due east, or west; in this case he is east at 8m. after 7 of the clock in the forenoon, and west at 52m. after 4 in the afternoon.

In this triangle may problem 18, 19, 20, 21, 22 and 23, of section 2. of this chapter be resolved.

Problem 4. *The same given as before in Problem 2. to find the Sun's Distance from the Vertex; and his Azimuth at the hour of six. Plate 8. fig. 1.*

Example.

The { latitude——51d. 32m. N. / sun's place ♊ 00 00 } given; the sun's { zen. dist. / azimuth. } at six of the clock, is required.

1. To delineate this, after the proper Meridian, and Path of the Vertex is drawn, as before in problem 2. Then thro' P, draw a great circle, at right angles with the proper Meridian, to cut the path in b, and in e; and the horizon of the earth's disk in A; where it always intersects the Æquator; as the oblique circle A bPe,

bPe, Able; which is the Meridian or Hour Circle of 6, so that b (in the Path) is the place of the Vertex at 6 in the morning; and e. its place when 6 afternoon.

2. Therefore thro' ⊙, and b; or ⊙, and e, draw a great circle, and you will form two right angled triangles bP⊙, or eP⊙; one of them is sufficient to solve the question, being equal triangles: if you take the first at 6 in the morning; it follows.

In the right angled triangle bP⊙. Plate 8. fig. 1.

1. The leg bP; the distance of the Pole from the Vertex, or the Complement of the Latitude; in this Example 38d. 28m.

2. The leg P⊙, the Sun's distance from the Pole found by prob. 1. to be 69d. 48m. the complement of the reflection.

3. The hypotenuse b⊙, the Sun's distance from the Vertex, or complement of his Altitude at the hour of 6.

4. The angle bP⊙, his Azimuth from the north, in all north latitudes, and the contrary in south latitudes: for in what part of the Path soever the vertex is found, that part of the hour circle, intercepted betwixt it and the North Pole, of the globe, is the north part of that meridian, or hour circle; and intercepted betwixt it and the south pole, is the south part of the meridian.

5. For the hypotenuse b⊙ the Sun's zenith distance at the hour of 6, the proportion by chapter 5. section 4. problem 5. case 14. in pages 129 and 130. is thus;

Radius ·· S. c. leg Pb :: S. c. leg P .. S. c. hypot. b⊙

S. 90d. .. S. 51d. 32m. :: S. 20d. 12m. ·· S. 15d. 41m. sun's altitude at 6 in the morning or afternoon.

That is;

As radius is to the sine of the latitude;

So is the sine of the reflection, to the sine of the sun's altitude, or complement of his distance from the vertex, at the hour of 6, 74d. 19m.

2. For the angle Pb⊙, his azimuth at 6, the proportion is thus;

As radius ·· S. leg Pb :: T. c. leg P⊙ .. T. c. angle Pb⊙.

As S. 90d. ·· S. 38d. 28m. :: T. 20d. 12m. ·· T. 12d. 53m. Sun's azimuth from the east, at 6 in the morning; but from the west at 6 in the afternoon.

That is;

As the radius is to the sine complement of the latitude;

So is the tangent of the reflection to the tangent complement of the sun's azimuth from the meridian, at the hour of 6, in this case it's 77d 07m. from the north; that is, almost E. by N. at 6 in the morning, and near W. by N. at 6 in the afternoon.

In this triangle may problem 12, 13, 14, 15, 16 and 17, of section 2. of this chapter be solved.

P Problem

Problem 5. *The sun in the equinox, the latitude of a place, and his altitude given; to find his azimuth, and the hour of the day.*

Note; The sun is said to be in the Equinox, when he is in the beginning of ♈, or ♎; and then he hath no declination.

Ex. The {latitude---51d. 32 N / ☉ altitude 33d. A.M.} given; the {sun's azimuth. / hour of the day} required. To delineate this. Plate 8. figure 1.

1. Supposing the sun in the beginning of ♈, and then the horizon of the earth's disk's is ♋ AC ♑, and the proper meridian then is ♈ P ♎: the sun's rising at London is at m, his setting at t, &c. The path of the vertex being drawn as before in problem 2.

2. Then (by problem 9. case 2. of Spherical Geometry, in page 112.) draw a parallel circle at 57d. distance from ♈, to cut the path in b; the place of the vertex of London when its distance from the sun is 57d. the complement of the given altitude.

3. Draw a meridian through P and b; as also a great circle through b and ♈, the place of the sun, so will you form the triangle ♈Pb, and bPK; either of them will solve the question: as,

In the right angle triangle PKb. Plate 8. figure 1.

1. The Hypotenuse Pb, the distance of the pole from the path of the vertex, or complement of the latitude, 38d. 28m.

2. The leg Kb, the sun's altitude, or the complement of his distance from the vertex, 33 degrees.

3. The angle PbK (the supplement of the angle Pb♈, the sun's azimuth from the north) the sun's azimuth from the south, in all north latitudes; but from the north in south latitudes.

The angle bPK, the complement of the angle bP♈ (the Hour from Noon) is the hour of the day from 6.

1. For the angle PbK, the azimuth from the meridian, the proportion (by chapter 5. section 4. Problem 1. case 1. in page 125.) is thus;

As radius -- T. c. hypot. Pb :: T. leg Kb -- S. c. angle PbK.

As T. 45d. -- T. 51d. 32m. :: T. 33d. -- S. 54d. 49m. the Sun's azimuth from the east. That is;

As the radius is to the tangent of the latitude;

So is the tangent of the sun's altitude (when in the equinox) to the sine complement of his azimuth from the South, that is 35d. 11m. S Easterly, or S. E. by S. 1 E. almost.

2. For the angle PbK, the hour from 6. the Proportion is thus;

As

As S. hypot. Pb ∙∙ radius S. :: leg Kb ∙∙ S. angle bPK.
As S. 38d. 28m. ∙∙ S. 90d. :: S. 33d. ∙∙ 61d. 06m. or 4h. 4m.

That is;

As the sine complement of the latitude is to the radius;
So is the sine of the sun's altitude (when in the Equinox) to the Sine of the hour from 6. 61d. 06m. equal to 4h. 4m. which makes 4m. after 10 in the morning; but had it been in the afternoon, then it's 56m. after 1.

In the same triangle, 5 problems more may be resolved, which I leave the learner to invent.

Problem 6. *The latitude of a place, the sun's place in the ecliptic, and his observed distance from the vertex given; to find his azimuth, and hour of the day.* *Example.*

The	latitude——51. 32 N sun's place ♊ 00. 00 his altitude 36. 00 AM	given; the	sun's azimuth hour of the day	required

To delineate this. Plate 8. figure 1.

1. Draw a parallel circle, 54d. distance from ☉, (the place of the sun) and where it cuts the Path (of the Vertex) is the place of the Vertex, when its distance from the Sun is 54d. or when the Sun's Altitude is 36d. as here it doth at 7 and 5.

4. Thro' 7, and P; and thro' 7, and ☉ draw great circles, which will form the triangle ☉P7; the like may be done thro' 5, which will form another triangle equal in all its parts to this, so that one is sufficient; wherefore observe.

In the Oblique Triangle ☉P7. Plate 8. figure 1.

1. The side P☉, the distance of the Sun from the Pole, found by Problem 1. to be 69d. 48m. the complement of the reflection 20d. 12m.
2. The side P7, the distance of the Pole from the Vertex, or the Complement of the Latitude, in this example 38d. 28m.
3. The side ☉7, the Sun's distance from the Vertex, or the complement of his altitude in the forenoon 54d. 00m.
4. The angle P7☉, the Sun's azimuth from the north.
5. The angle D☉P7, the Hour of the Day from Noon.

The angles P7☉ and ☉P7, may be found by chapter 5. section 5. problem 11. case 11. of Oblique Spheric Trigonometry, in pages 136 and 137. for here are three sides given; to find an angle, and when wrought you'll find the angle P7☉ 103d. 12m. the azimuth, from the north, or 76d. 48m. from the south easterly, which makes E. by S. almost.

And the angle ☉P7 is 57d. 04m. or 3h. 48m. the hour from noon, which makes 12m. after 8 in the morning.

But had it been in the afternoon, then the hour would be 48m. after 3, and the azimuth 76d. 48m. south westerly or W. by S. almost.

 In

In this triangle may prob. 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10, of section 3. of this chapter be solved.

Problem 7. *The longitude and latitude of a star given; to find its right ascension and declination.*

Example. Let the proposed star be Capella, and supposing its longitude ♊ 18d. 02m. } what is its { right ascension ? latitude—— 22d. 52m. north } { declination?

To delineate this problem. Plate 8. figure 1.

1. Lay off the star's longitude 78d. 02m. (from the chords) on the primitive circle, from ♈ to y, and draw the circle of longitude K y.

2. From the half-tangents, lay 67d. 08m. (the complement of the star's latitude, or its distance from the nearest pole of the ecliptic) on the circle of longitude from K to ✱.

3. Thro' P, and ✱, draw a meridian, that is a great circle, and it's done.

Then in the oblique triangle KP✱. Plate 8. figure 1. Observe;

1. The side PK, the distance of the two poles, or line of the direction of the earth's axis always; 23d. 30m.

2. The side K ✱, the Star's distance from the Pole of the Ecliptic, or its complement of latitude, equal to 67d. 08m.

3. The angle PK✱, the star's longitude from the Solstitial Colure, in this problem is 11d. 58m.

4. The angle K P ✱, the star's right ascension from the same colure.

5. The side P✱, the star's distance from the pole of the globe; or complement of his declination.

So that here are two sides, and an angle between them given; to find an angle, and the third side; which is performed by chapter 5. section 5. problem 9. case 7 and 8, of Oblique Spherical Triangles in pages 134 and 135, and being the same as problem 11. of section 3. of this chapter, in page 216. I leave it to the learner's working.

Problem 8. *The latitude of a place, the sun's place in the ecliptic, and the time of the day given; to find what point of the ecliptic culminates in the meridian; the highest point in the ecliptic (called the Nonagesima Degree or 90th Degree of the ecliptic) the distance of each of these from the Vertex, and the Parallactic Angle, or angle which the vertical circle makes with the ecliptic.*

It's usual to find these things in the calculation of Eclipses, and the Moon's passing over fixed Star's; which in the Ptolemaic Projection

Projection, are with much difficulty shewn, but in this most readily and easily represented.

Example.

Latitude——51. 32 N } given; the { Point culminating }
Sun's place ♊ 00. 00 } given; the { Nonagesima degree }
Hour——— 9h. A M } given; the { Vertical distance of each }
required. To delineate this. Plate 8. figure 1.

1. The sun's place, proper meridian, and path of the Vertex, being drawn as before, draw an hour circle, or meridian thro' P. 45d. (the distance of the given hour 9) from the proper meridian, as P 9, to cut the path of the Vertex in 9, and the earth's ecliptic in C and in F.

2. Thro' ⊙9, and D, draw a vertical circle; and thro' K, and 9, draw a circle of longitude, to cut the primitive circle in N, and it's done. For.

1. C is the point of the ecliptic culminating, or in the meridian of the place, at the given time.

2. N is the Nonagesima Degree, or the highest point of the ecliptic, at the same time.

3. C 9, and N 9, are their respective distances, from London's Vertex at that time.

4. The angle N⊙9, is the parallactic angle, or angle which the Vertical circle, makes with the ecliptic at the same time.

Then the rectangle triangle P♋C.

1. The angle CP♋, is the complement of the right ascension of the Mid-heaven, or point of the ecliptic in the meridian of the place at the proposed time, being the time from noon (when afternoon added to the sun's right ascension, found by Problem 1. But when the proposed time is in the forenoon subtracted) in this case is 77d. 11m. the complement of 12d. 49m. found by subtracting (the time) 45d. from 57d. 49m. the sun's right ascension.

2. The leg P♋, is the complement of the distance of the poles of the globe, and ecliptic, equal to 66d. 30m.

3. The leg C♋, is the complement of ♈ C, the longitude of the Mid-heaven, or the point of the ecliptic culminating in the meridian, at the proposed time.

4. The hypotenuse CP, the distance of the Mid-heaven from the next or nearest pole of the globe, at the said time.

1. For the leg C ♋, the point culminating, the proportion by chapter 5. section 4. problem 3. case 7. in pages 127 and 128. is thus;

As radius ·· S. leg P♋ :: T. angle CP♋ ·· T. leg C♋.

As S. 90d. ·· S. 66d. 30m. :: T. 77d. 11m. ·· T. 76d. 02m. whose complement 13d. 58m. is ♈C; therefore the Mid-heaven is ♈ 13d. 58m.

2. For the hypotenuse CP. the Proportion is thus;

 Radius

Radius .. S. c, angle CP♋ :: T. c. leg P♋ ·· T. c, hypotenuse CP.
S. 90d. ·· S. 12d. 48m. :: T. 23d. 30m. ·· T. 05d. 30m. whose complement 84d. 30m. is PC, from which take away P9, the distance of the pole from the Vertex 38d. 28m. the remainder is 9C, the distance of the Mid-heaven from the Vertex 46d. 02m. Then in the oblique triangle P9K.

1. The side PK, the distance of the two Poles 23d. 30m.

2. The side P9, the complement of the latitude of the place, 38d. 28m.

3. The angle KP9, the difference of the right ascension of the Mid-heaven; and first point of ♑; in this case 102d. 48m. found by subtracting 270 degrees, out of (12d. 48m. added to) 360 degrees being 372d. 48.

4. The angle PK9, the longitude of the Nonagesima from the first point of ♋.

5. The side K9, the complement of the Nonagesima's distance from the Vertex.

First, For the angle PK9, the proportion by chapter 5. section 5. problem 9. case 7. in pages 134 and 135. is thus,

1. As the sine of ½ the sum of the sides P9, and PK, is to the sine of ½ their difference.

So is the tangent complement of ½ the angle KP9, to the tangent of half the difference of the angles P K 9, and P 9 K, Then,

2. As the sine complement of ½ the sum of the sides P9, and PK. is to the sine complement of half their difference.

So is the tangent complement of half the angle KP9, to the tangent of half the sum of the angles PK9, and P9K.

That is,

	d. m.		d. m.		d. m.		d. m.	
1. As the S.	30. 59.	·· S.	07. 29.	:: T.	38. 36.	·· T.	11. 25.	and
2. As the S.	59. 01.	·· S.	82. 31.	:: T.	38. 36.	·· T.	42. 43.	which

being added, is the angle PK9 ———————— 53. 08. or ♋N.
subtract from — — — — —90. 00.
Remainder is the longitude of the Nonagesima 36. 52. from ♈
That is, the place of the Nonagesima is 6d. 52m. in ♉.

Secondly, For the side K9, the proportion is thus;
As S. angle PK9. ·· S. side P9 :: S. angle KP9 ·· S. side K9.
As S. 54d. 08m. ·· S. 38d. 28m. :: S. 102d. 48m. ·· S. 48d. 28m. the distance of the vertex from the pole of the ecliptic, equal to which is the altitude of the Nonagesima, whose complement 41d. 32m. is N9, its distance from the vertex.

Again, in the rectangle triangle ☉N9.

1. The leg ☉ N, the sun's distance from the Nonagesima, in this case 24d. 08m. found by subtracting ♈N 36d. 52m. from ♈ ☉ 60d. 00m.

2. The

2. The leg N9, the distance of the Nonagesima from the vertex; found as before, is 41d. 33m.

3. The hypotenuse ⊙9, the sun's distance from the Vertex.

4. The angle N⊙9, made between the vertical circle and the ecliptic, is the Parallactic angle: to find which, the proportion (by chapter 5. section 4. problem 5. case 13. in pages 129 and 130.) is thus,

As radius ·· S. leg ⊙N :: T. c. leg. N9. ·· T. c. angle N⊙9.
As S. 90d. ·· S. 24d. 08m. :: T. 48d. 28m. ·· T. 24d. 47m. whose complement 65d. 13m. is the Parallactic Angle N⊙9 at the sun.
And for ⊙9, the sun's distance from the vertex, is thus found.
As radius ·· S. c. leg ⊙N :: S. c. leg N9. ·· S. c. hypot. ⊙9.
As S. 90d. ·· S. 65d. 52m. :: S. 48d. 47m. ·· S. 43d. 05m. whose complement 46d. 55m. is the sun's distance from the vertex, at the proposed time.

But to calculate the Parallactic Angle, at the Moon, or at a Star, that has latitude from the ecliptic, it will require a little more labour, as in the next problem.

Problem 9. *The latitude of a place, sun's place in the ecliptic, time of the day or night, and the longitude, and latitude of the Moon, or of a Star, being given; to find the Parallactic Angle at the Moon, or at the Star; and its distance from the Vertex.*

Example.

Latitude—	— 51. 32.	given; the	Parallact. Ang. and Vertical dist.	req.
Sun's place	— ♊0. 00.			
Hour —	—9h. A.M.			
Star capella lon.	18.02. ♊			
It's latitude	—22.52.N.			

To delineate this. Plate 8. figure 1.

1. Lay off the sun's longitude, and draw the proper meridian path of the vertex, the hour circle according to the proposed time, the vertical circle, and circle of longitude, in all respects as before in problem 8.

2. Lay off the Star's longitude and latitude, as before in problem 7. and then is N the place of the Nonagesima, 9. the vertex, and ✳ the star's place.

3. Through ✕, and 9, draw a circle, and it's done.

For ✳9, is the star's distance from the vertex; and the angle K✳9, the complement of the parallactic angle required: in order to the finding them by Calculation, do thus;

First, Find the place of the Nonagesima by problem 8, which in this case is ♉ 6d. 52m. or ♈ N. 36d. 52m.

Secondly, The Nonagesima's distance from the vertex, in this case N9. is 41d. 32m.

Then

Then the oblique triangle ✱K9, observe,

1. The side K✕, the star's distance from the next Pole of the ecliptic or the complement of its latitude; 67d. 08m.

2. The side K9, the distance of the vertex from the said Pole, which is equal to the altitude of the Nonagesima, 48d. 28m. found by problem 8.

3. The angle ✕K9, the difference of the longitude of the given star, and the Nonagesima; and in this example is 42d. 10m. and is the difference of ♈ N 36d. 52m. and ♈ y 78d. 02m.

4. The angle K✛9, the complement of the parallactic angle, at the given star.

5. And the side ✕9, the star's distance from the vertex.

First, To find the angle K✕9, the proportion by chapter 5. section 5. problem 9. cases 7. in pages 134 and 135. is thus.

1. As the S. of half the sum of the sides K✕, and K9; is to the sine of ½ the difference; so is the tangent complement of ½ the angle ✛K9; to the tangent of ½ the difference of the angles K9✕ and K✕9. Then.

2. As the sine complement of ½ the sum of the sides K✕, and K9; is to the sine complement of ½ their difference;

So is the tangent complement of ½ the angles ✕K9; to the tangent of ½ the sum of the angles K9✕, and K✕9.

That is;

	d. m.		d. m.		d. m.		d. m.	
1. As the	S. 57. 48.	∙∙	S. 9. 20	::	T. 68. 55.	∙∙	T. 26. 26.	And
2. As the	S. 32 12.	∙∙	S. 80.40.	::	T. 68. 55.	∙∙	T. 78. 14.	They

being subtracted give the angle K✕9 ——— 51. 48. whose complement 38d. 21m. is the parallactic angle at Capella.

Secondly, To find ✕ 9 the vertical distance, the propor. is thus
As S. angle K✕9. ∙∙ S. side K9. :: S. angle ✕K9. ∙∙ S. side ✕9.
As S. 51d. 48m. ∙∙ S. 48d. 28m. :: S. 42d. 10m. ∙∙ S. 39d. 45m.
The distance of the star Capella from the vertex at the time proposed.

I might proceed to other Problems, and shew how they are formed and represented in this Projection, but I leave that for the learner's exercise.

I pass by what (at first) I intended, which was the orthographical projection of the globe; whereby the Moon's Appulses to the Sun or Stars, and all the appearances of an eclipse, occultation or transit, are represented to the eye: useful to find the longitude of places, on the globe of the Earth, a thing much talked of, greatly desired, and by some pretended to be found, tho' not made known, and I believe will never be made practicable at sea. However, by this hypothesis, with accurate tables of the Moon and Stars places; and a way of taking an

Altitude

Place this next after Page 232.

Fig: I

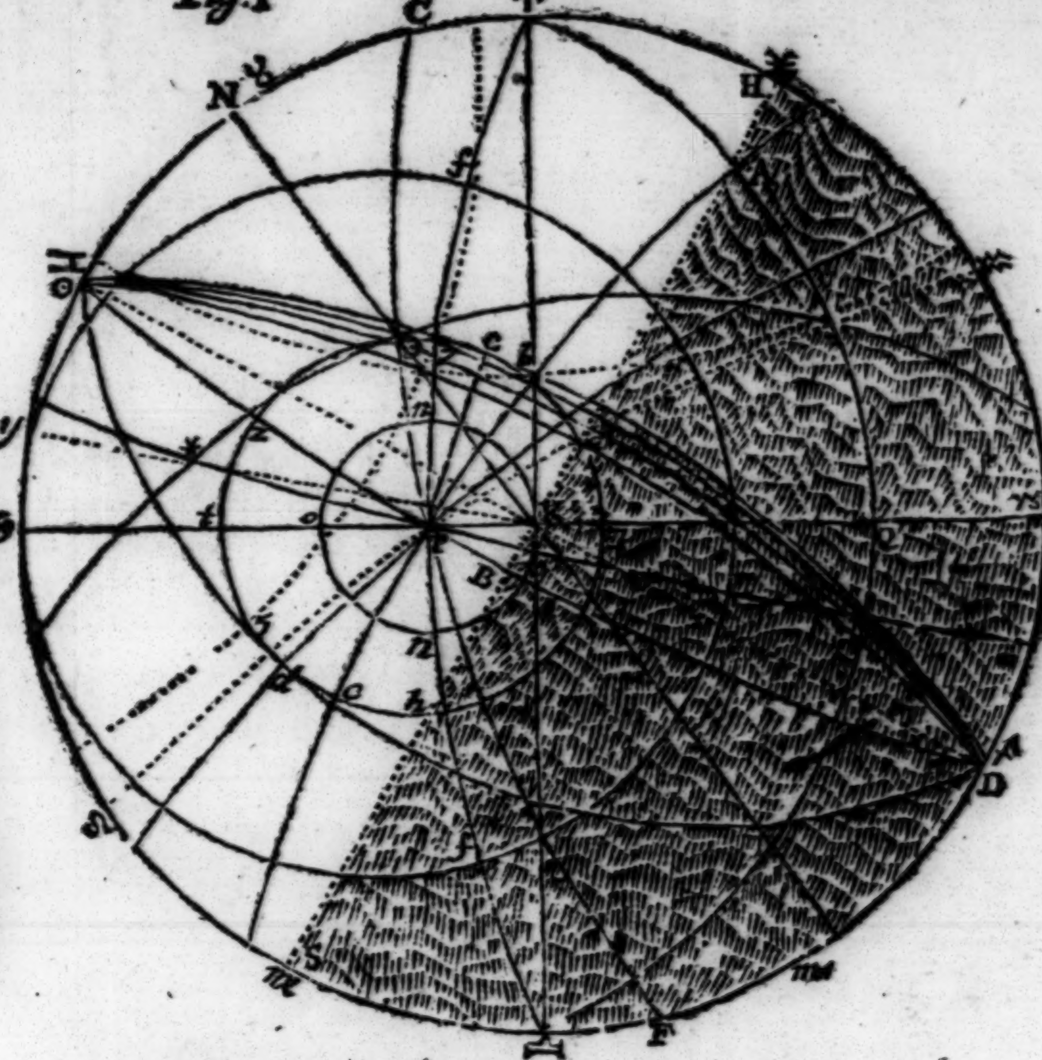


Fig. II.

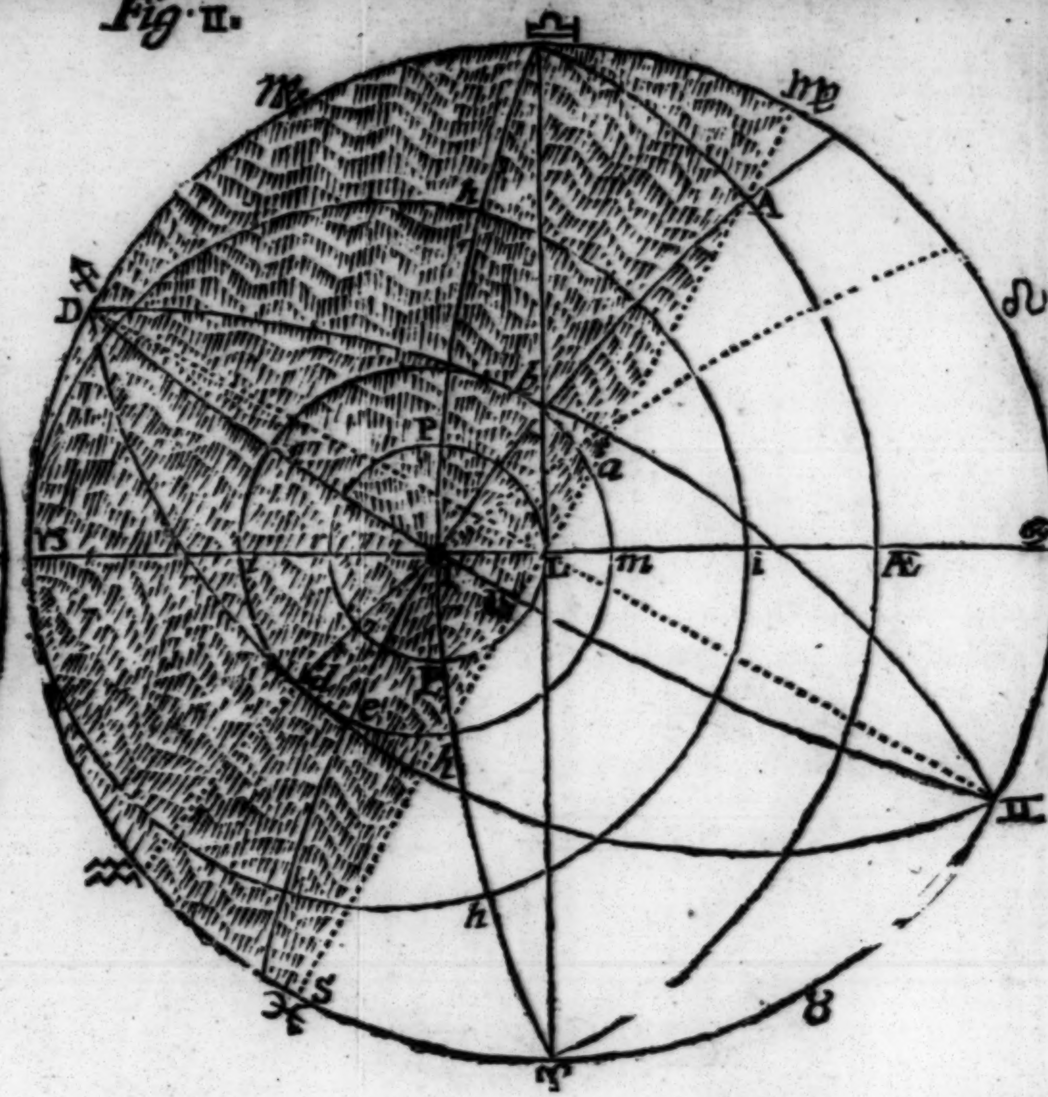
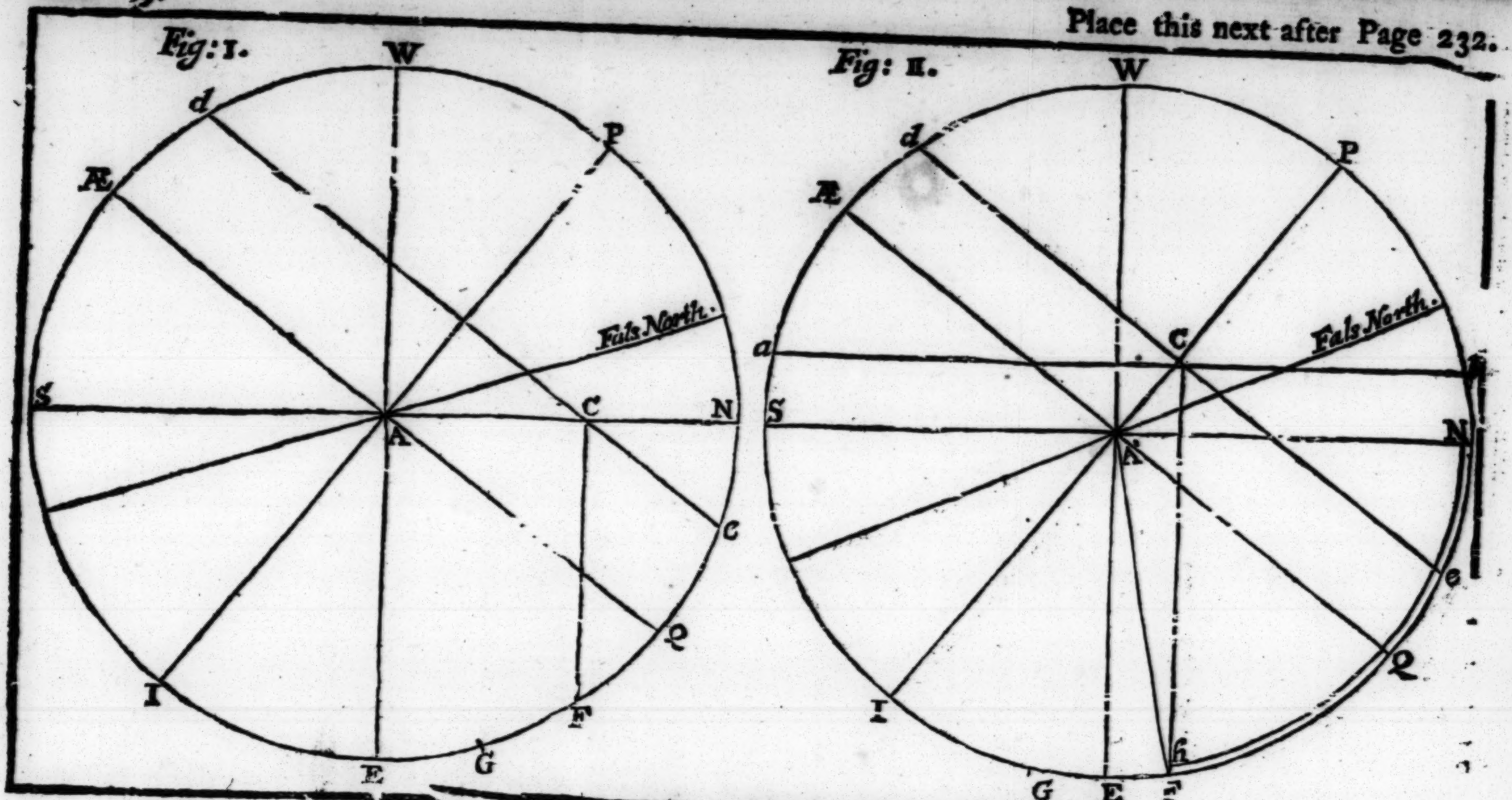


Plate 9.

Place this next after Page 232.



Altitude or an Angle at Sea unto two or three minutes; it might be made useful to observe for longitude, and therefore it's highly worthy of our Seamen's study, but without such Altitudes, it will not find the Longitude unto two or three degrees: and for encouragement thereunto the Government hath by an Act of Parliament promised thousands of Pounds; and for the Learner's help herein, I am ready to communicate all the assistance I can elsewhere; for here's now no place for it, lest the book (swelling two big) should be deformed.

And note; these two figures in plate the 8th, are a representation of the two Hemispheres before described in chapter 6. section 4. in pages 166 and 167. So that in those larger, all these problems might be more exactly formed, and their requisites more truly measured; and if the particular circles belonging to any problem, such as the proper meridian, other meridians, or hour circles, path of the vertex, circles of longitude, and vertical circles, to a particular time, &c. were drawn with black lead, they might be wiped out at pleasure, and the Hemispheres no way damnified.

And when any circle happens so large as not easily to be drawn, or struck with compasses it may be done with a bow of the length of the diameter of the Hemispheres; such being well made with 3 screws, by their turning, will rise up to several circles, that may (in the Projection) be required to be drawn.

CHAP. X. *Of the variation of the compass, what it is, how to find it, and how to rectify the compass thereby.*

DEfinition 1. Variation of the Compass is an arch of the Horizon contained between the meridian of the place, and the magnetical meridian; it's either east, or west, and never exceeds 90 degrees.

2. East Variation, is when the north part of the magnetical meridian lieth eastward of the north part of the meridian of the place; but if to the westward, then its called West Variation.

3. Magnetical Meridian, is a great circle passing thro' or by the Magnetical Poles; to which meridian the compass (if not otherwise hindered) hath respect.

4. Magnetical Poles, are two moving opposite points, making their revolutions about the poles of the world (as Mr. Bond saith in his longitude found, page 7.) in 600 years in a circle 08d. 30m. distant therefrom; and their motion (as he saith) is the cause of the variation of the compass.

5. The Variation of the Compass is found by an Amplitude, or an Azimuth.

6. To

6. To find the Variation by an Amplitude, you must know the latitude of the place, the declination, and magnetical amplitude of the sun.

7. Magnetical Amplitude, is an arch of the Horizon, contained between the Sun (at his rising, or setting) and the east or west points of the compass steered by: or it's the apparent rising, or setting of the sun from the east, or west points of the said compass, and is found by observing the sun, either at his rising, or setting by an amplitude compass.

8. Amplitude, is an Arch of the Horizon, contained between the Sun and the East or west Points of the Horizon; and is found by chapter 9. section 2. problem 4. in pages 199 and 200, which I call the True Amplitude.

9. If the two foresaid Amplitudes agree; that is, the Magnetical and True Amplitude (which is seldom) there is no variation; but if they differ, their difference rightly counted is the variation.

Note here: If you always count both Amplitudes from the North; then this is a General Rule.

At sun rising $\left\{\begin{array}{l}\text{True}\\\text{Magnetical}\end{array}\right\}$ Amplitude greatest, the

Variation is $\left\{\begin{array}{l}\text{East}\\\text{West}\end{array}\right\}$ but at Sun setting it's $\left\{\begin{array}{l}\text{West}\\\text{East}\end{array}\right.$

Example 1. At Sun rising, suppose the True Amplitude be east 33 degrees northerly, and the Magnetical Amplitudes east 17 degrees northerly, then counting both these from the north, the True Amplitude will be north 57 degrees easterly, and the Magnetical north 73 degrees easterly; the Magnetical is the greatest, and the difference is 16 degrees, which is the Variation westerly: if this had been at Sun-setting, the Variation would then be easterly.

Example 2. At Sun-setting let the true Amplitude be west 16 degrees northerly, and the Magnetical Amplitude west 9 degrees southerly; both counted from the north, the True Amplitude is north 74 degrees westerly, and the Magnetical is 99 degrees from the north, and is the greatest; their difference is 25 degrees, which is the Variation easterly.

Or thus, in these two Rules:

1. The Amplitudes both north, or both south; their difference is the Variation: but one north, the other south, their sum is the Variation.

2. Both the Amplitudes (before your face) from you, if the True Amplitude be to the right-hand of the Magnetical, the Variation is east; but when its to the left-hand, then the variation is west.

These Rules will be exemplified in the Problems and Examples following.

Pro-

Problem 1. *The Latitude of the place, the Declination, and Magnetical Amplitude of the sun given; to find the Variation of the Compass.*

Example.

The $\left\{\begin{matrix}\text{latitude — —} & 51\text{d}. & 32\text{m}. \\ \text{sun's declination} & 20 & 10 \\ \text{magnetical amplitude} & 17 & 10\text{A.M.}\end{matrix}\right\}$ $\begin{matrix}\text{north given;} \\ \text{the variat. req.}\end{matrix}$

To delineate the problem orthographically. Plate 9. figure 1.

1. Describe a circle and quarter it; on whose diameter's place W.N.E. and S. (but always) Æ at the right-hand, and A at the center of the circle.

2. Lay the lat. if $\left\{\begin{matrix}\text{north}\\\text{south}\end{matrix}\right\}$ from $\left\{\begin{matrix}\text{N}\\\text{S}\end{matrix}\right\}$ upwards to $\left\{\begin{matrix}\text{P}\\\text{I}\end{matrix}\right\}$ and the same way laid from W. to Æ, and draw the axis PAI, and the equinoctial ÆAQ.

3. By laying the chord of the declination on the primitive circle, from the equinoctial, draw the parallel declination parallel to it, as the strait line Ce, to cut the horizon SAN, in C, the place of the sun's rising, or setting.

4. Measure AC on the line of sines, sheweth the sun's true amplitude north, if the declination be north: but south when the declination is south.

5. Draw the line CF, parallel to WAE (downward when its A.M. but upward if it be P.M.) to cut the primitive circle in F.

6. Lay the magnetical ampl. if $\left\{\begin{matrix}\text{A.M.}\\\text{P.M.}\end{matrix}\right\}$ from $\left\{\begin{matrix}\text{E}\\\text{W}\end{matrix}\right\}$ to G, on the primitive circle, towards N, if it be north; but towards S, when it is south.

7. The distance from G to N, laid (the same way) from F to False North, which is now the north point of the compass, and it's done.

For the distance from N to False North, measured on the Scale of Chords, is the variation required.

To find the true amplitude, the proportion by chapter 9. section 2. problem 4. in page 200, is thus;

As S. c. latitude .. radius :: S. ☉'s declinat. .. S. ☉ amplit:
As S. 38d. 28m. ·· S. 90d. :: S. 20d. 10m. N. .. S. 33d. 40 north.

	d. m.		d. m.	
True amplitude EF	33. 40.	E.N. or NF	56. 20.	north easterly
Magnetical——EG	17. 10.	EN or NG	72. 50.	north easterly
Subtract gives the variation to be——			16. 30.	west.

Example 2.

The $\left\{\begin{matrix}\text{latitude — —} & 40. & 50. \\ \text{sun's declination} & 10. & 19. \\ \text{magnet-amplitude} & 15. & 10.\end{matrix}\right\}$ $\begin{matrix}\text{north} \\ \text{south A. M.}\end{matrix}$ $\Big\}$ given; var. req.

Answ.

Answ. The true amplitude is 13d. 42m. east northerly, found by the foresaid proportion, by which the Variation is thus found.

	d. m.		d. m.	
True amplitude EF	13. 42. EN.	or NF	76. 18. N.	easterly
Magnetical — EG	15. 10. ES.	or NG	105. 10. N.	easterly
Subtract, gives the Variation to be			28. 10.	west

The following examples are for the learner's exercise, and are wrought by the foresaid directions and rules.

Example 3 d. m.

The { latitude — — 13. 10 north; sun's declination 15. 40 south; magnet. amplitude 9. 12S..PM. } given; var. required.

Answ. According to the foresaid rules, it's as follows:

	d. m.		d. m.	
True amplit. WF	16. 06. W.S.	or NF.	106. 06. N.	westerly
Magnetical WG	9. 12. W.S.	or NG.	99. 12. N.	westerly
Subtract gives the variation — . —			6 54	west.

Example 4. d. m.

The { latitude— — 50 40——; sun's declination 19 50——; magnet, amplitude 5 15P.M. } south given, variat. req.

Answ. The Variation is 25d. 47m. west.

Example 5. d. m.

The { latitude — —21 30—; sun's declination 17 56— } north; magnet. amplit. 10 19 south P. M. } given; variation required.

Answ. The Variation is 29d. 39m. east.

Example 6. d. m.

The { latitude — 25 30 south; sun's declination 18 12 north; magnet. amplit. 9 50S.A.M. } given; variat. required.

Answ. The Variation is 30d. 06m. west.

Secondly, To find the Variation of the Compass by an Azimuth. Observe these following Definitions.

1. Magnetical Azimuth, is an arch of the Horizon contained between the Sun's Azimuth Circle, and the Magnetical Meridian. Or it's the apparent distance of the sun from the north, or south point of the Compass; and it's found by observing the sun by the Azimuth Compass, either in the forenoon or afternoon, when he is about 5 or 10 degrees high.

2. Azimuth, is an arch of the Horizon contained between the azimuth circle passing over the sun, and the meridian of the place, which I call the True Azimuth. and is found by chapter 9. sect. 3. problem 1. of Astronomy, in pages 212 and 213.

3. If the said azimuths agree; that is, if the True Azimuth and Magnetical Azimuth agree, there is no variation; but if they

they differ, their difference is their variation; which, rightly to account, observe this general rule.

Reckon always both Azimuths (like as I said for amplitude in page 253.) from the north.

In the forenoon the $\left\{\begin{array}{l}\text{true———}\\ \text{magnetical}\end{array}\right\}$ azimuth greatest, the variation is $\left\{\begin{array}{l}\text{east}\\ \text{west}\end{array}\right\}$ but in the afternoon its $\left\{\begin{array}{l}\text{west}\\ \text{east}\end{array}\right.$

Example 1. In the forenoon, suppose the true azimuth from the north to be 80 deg. and the magnetical azimuth at the same time to be 101 degrees, the magnetical is the greatest; and their difference 21 degrees is the variation of the compass westerly; but easterly, had it been in the afternoon.

Example 2. In the afternoon, let the true azimuth be 115 degrees, and the magnetical azimuth 101 degrees, their difference 14 degrees is the variation westerly, but easterly had it been in the forenoon.

Or thus, by the rules following.

1. Always count both azimuths from the north, in north latitude; but from the south in south latitude.

2. The lesser azimuth subtract from the greater, gives the variation.

3. Placing both the azimuths (before your face) from you, if the true azimuth be to the right-hand of the magnetical, the variation is east. But if to the left-hand the variation is west.

These rules will appear plain, in the working the examples of the next problem.

Problem 2. *The latitude of the place, the sun's altitude, sun's declination, and his magnetical azimuth given, to find the variation of the compass.*

Example 1.

$$\text{The}\left\{\text{sun's}\left\{\begin{array}{lll}\text{latitude} & — & 51.\ 32\ \text{north}\\ \text{altitude} & — & 11.\ 30\ \text{A.M.}\\ \text{declination} & & 15.\ 10\ \text{north}\\ \text{magn. azim.} & & 101.\ 10\ \text{north}\end{array}\right\}\right.\text{given: variation required.}$$

To delineate the Problem Orthographically, plate 9. fig. 2.

1. Describe a circle, quarter it, lay off the latitude, draw the equinoctial, axis, and parallel of declination; in all respects as before directed (in problem 1. page 235.) concerning an amplitude.

2. By laying the chord of the sun's altitude on the primitive circle from the horizon SAN; draw the parallel of altitude parallel to the horizon SAN; as the line aCb, to cut the parallel of declination dCe, in C; the place of the sun at that time.

3. Draw C h parallel to W A E, downward when its A. M. but upwards if it be P. M. till it meet an arch (made with half the parallel of altitude) from the center (of the primitive circle) A, and cutteth the said arch in h.

4. By

4. By A and h, draw a line, to cut the primitive circle in F; then NF, or SF, measured on the scale of Chords sheweth the sun's true azimuth.

5. Lay the magnetical azimuth (if $\left\{\begin{matrix}\text{north}\\ \text{south}\end{matrix}\right\}$ latitude) from $\left\{\begin{matrix}\text{N.}\\ \text{S.}\end{matrix}\right\}$ (towards $\left\{\begin{matrix}\text{E.}\\ \text{W.}\end{matrix}\right\}$ when it is $\left\{\begin{matrix}\text{A. M.}\\ \text{P. M.}\end{matrix}\right\}$) to G on the primitive cir. but if $\left\{\begin{matrix}\text{PM}\\ \text{AM}\end{matrix}\right\}$ towards $\left\{\begin{matrix}\text{W.}\\ \text{E.}\end{matrix}\right\}$ to the said G.

6. The distance from G to N, laid (the same way) from F to false north, which is now the north point of the compass, and it's done.

For the distance from N to false north, measured on the scale of chords, is the variation of the compass required.

Then to find the true azimuth, the proportion by chapter 9. section 3. problem 1. in pages 211 and 212. is thus,

d. m.	d. m.	d. m.
90. 00	90. 00	90. 00
Latitude ——— 51. 32 N.	⊙ alt. 11. 30 A. M.	⊙ decl. 15. 10 N.

Compl. latitude 38. 28	Com ⊙ alt. 78. 30 ⊙ dist. fr. pole 74. 50
Compl. altitude 78. 30	Radius ·· S. c. lat. :: Sc. ⊙ alt. ·· a 4th sine
⊙s dist. from pole 74. 50	S. 90d. ·· S. 38. 28. :: S. 78. 30. : S. 37. 33
Sum is — — 191. 48	Then again.
The ½ sum is — 95. 54	4th sine ·· S. ½ sum :: S. rem. : a 5th sine
The remainders 21. 04	S. 37. 33. ·· S. 95. 54. :: S. 21. 04. : S. 95. 55.
And against S. 35. 55	on the versed sines is the

⊙'s true azimuth — — — 80d. 02m. north easterly
⊙'s magnetical azimuth — — 101d. 10m. north easterly
Subtract giveth the variation — — 21d. 08m. west.

And for the learner's Practice, take these following Examples, whose answers are found by the rules foregoing.

Example 2.

The { latitude — — 13 10 north; sun's { altitude — 17 50 A. M.; declination 16 59 south; magnet. azim. 90 10 north } given : variation required.

d. m.	d. m.	d. m.
90. 00	90, 00	90. 00
Latitude — —13. 10 N.	⊙'s alt. 17 50. A. M.	⊙'s decl. 16 59. S.

Comp. latitude 76. 50	Comp. alt. 72. 10. ⊙'s dist. fr. pole 106. 59
Comp. ⊙ altitude 72. 10	Radius ·· S. c. lat. :: Sc. ⊙'s alt. at 4th sine
⊙'s dist. fr. pole 106. 59	S. 90d. ·· S. 76. 50 :: S. 72. 10 ·· S. 67. 58.
Sum is— — 255. 59	Then again,
The ½ sum — 127. 59	4th sine ·· S. ½ sum :: S. rem. ·· a 5th sine
The remainder is 21. 00	S. 67. 48. ·· S. 127. 59 :: S. 21. 00 ·· S. 17. 45.

— — — — —

And

And again S. 17.45. on the versed sines, is the
☉' true azimuth — — —113d. 00m. north easterly.
☉' magnet azimuth — — 90d. 10m. north easterly.

Subtract giveth the variation — 22d. 50m. east.

Example 3. d. m.

The { latitude — — —28 40 north
sun's { altitude — 20 19 P. M.
declination — 19 12 south
magnet. azim. 129 50 north } given: variation required.

Answer. By the foresaid directions, the
☉'s true azimuth — — 127d. 02m. nor. westerly.
☉' magnetical azimuth — 129d. 50m. nor. westerly.

Subtract giveth the variation —2d. 48m. east.

Example 4. d. m.

The { latitude — — —50 40 south
sun's { altitude — 25 10 P. M.
declination —23 30 south
magnet. azim. 100 20 south } given; variation required.

Answer. The variation is 17d. 20m. west.

Example 5. d. m.

The { latitude — — — 23 10 south
sun's { altitude — 10 15 A. M.
declination — 23 30 south
magnet. azim. 102 40 south } given: variation required.

Answer. The variation is 18d. 32m. west.

Example 6. d. m.

The { latitude — — —37 45 south
sun's { altitude — 18 20 P M.
declination — 20 15 north
magnet. azim. 115 40 south } given: variation required.

Answer. The variation is 20d. 12m. east.

But the variation may be found most readily by an instrument called a Rectifier, whose description is as follows;

This instrument consisteth of two parts, which are two Circles laid one upon another, and so fastned together in their centers, that they represent two compasses, one fixed, the other moveable; each of them is divided into the 32 points of the compass, and 360 degrees, and numbred both ways, from the north, and from the south; ending at the east and west, in 90 degrees.

The fixed Compass, represents the horizon, in which the north, and all the points of the compasses are fixed, and immoveable.

The

The moveable one, repreſents the mariner's compaſs ſteered by, in which the north, and all other points are liable to variation.

In the center of the moveable compaſs, is faſtned a ſilk thread, long enough to reach the outſide of the fixed compaſs; but when its made of wood, there is an index inſtead thereof: the uſe is as follows.

1. *To find the variation by the Rectifier.*

Note; Thoſe degrees numbred from the north, and the ſouth, towards the eaſt, are termed the right-hand; and the others towards the weſt, are called the left-hand.

Example 1. *At ſun riſing ſuppoſe the true amplitude* 57d. *from the north, and the magnetical* 73d. *What is the variation of the compaſs, and which way?*

Place 73d. (from the north) on the right-hand in the moveable compaſs, to 57d. (from the north) on the right hand in the immoveable compaſs; then the north point of the moveable compaſs, will ſtand at 16d. of the left-hand in the immoveable compaſs, which ſheweth the variation of the compaſs is 16 degrees weſt.

Example 2. *In the afternoon, let the true azimuth be* 80 *degrees from the north, and the magnetical* 101 *degrees. What is the variation of the compaſs, and which way?*

Place 101d. from the north: that is 79d. from the ſouth on the left-hand in the moveable compaſs, to 80 deg. from the north, or left-hand in the moveable compaſs; then the north point in the moveable compaſs, ſtands at 21d. on the right-hand in the immoveable compaſs, which ſhews the variation of the compaſs to be 21 degrees eaſt.

Always counting amplitude at ſun-riſing, and azimuth in the forenoon, to the right-hand, or towards the eaſt; but at ſun-ſetting, and in the afternoon, count them to the left-hand towards the weſt.

2. *To rectiſy the courſe by the Rectifier.*

This propoſition hath two caſes.

Caſe 1. The variation of the compaſs, and the courſe ſteered, being given; to find the true courſe.

Example 1. *Suppoſe the Variation be* 21 *degrees eaſt, and the courſe ſteered by the Compaſs is N. E. by N. I demand the true courſe, the Variation being allowed.*

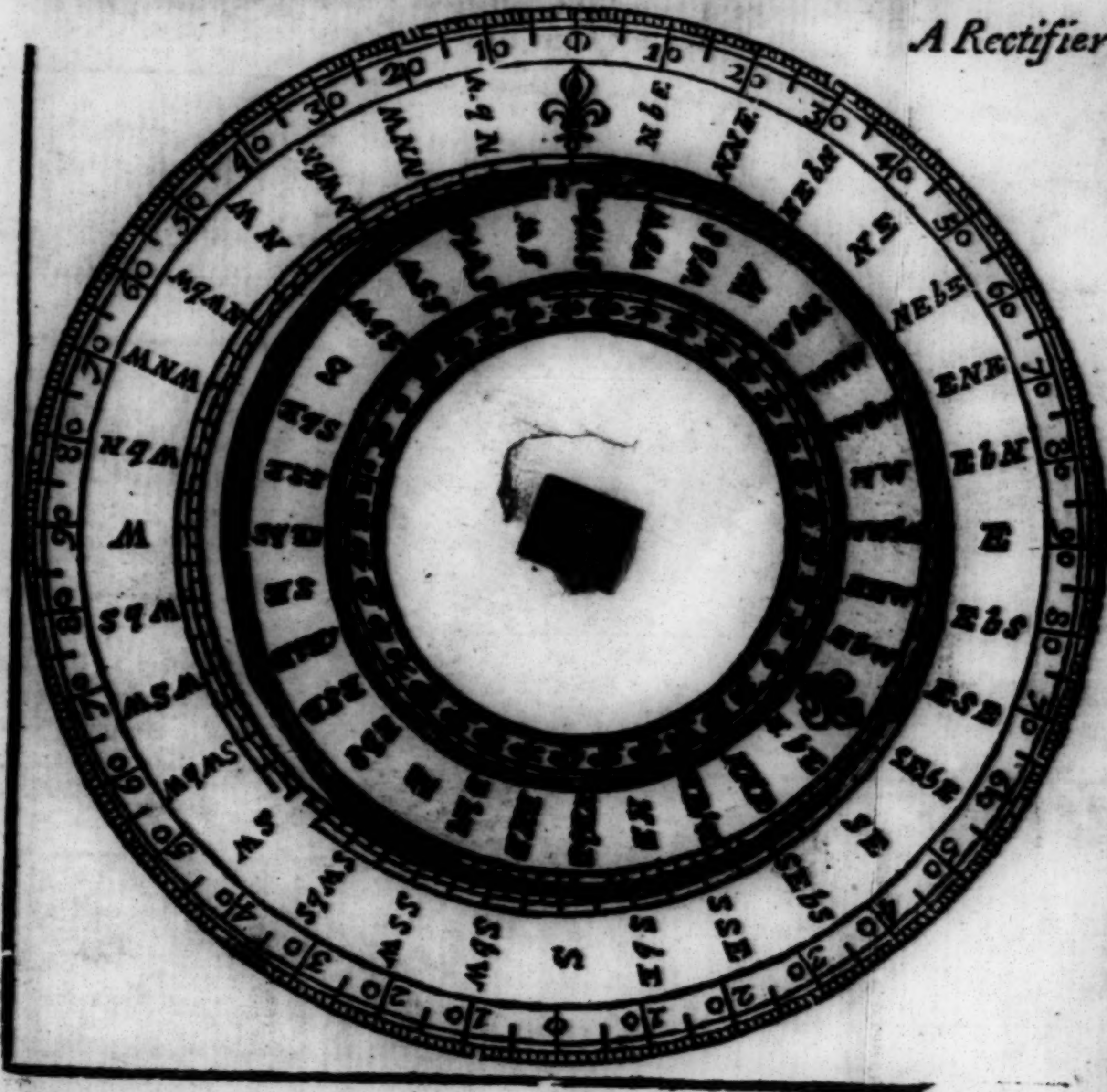
1. Place the north point of the moveable compaſs to 21d. from the north on the right-hand, in the immoveable compaſs

2. Lay the thread or index (which is faſtned in the center) over the N. E. by N. point in the moveable compaſs, keeping it ſtraight out; then in the moveable compaſs the thread or index, will lie in 56 degrees, or near N. E. by E. which is the true courſe required.

Example

Plate 10th to front Page 240.

A Rectifier.



Example 2. *The Variation* 14 *deg. weſt, and the courſe by the compaſs, E.S.E. I demand the ſhip's true courſe?*

1. Place the north in the moveable compaſs, to 14 degrees weſt, in the immoveable.

2. Stretch out the thread, or index, over E.S.E. in the moveable, and it will lie on 82 degrees in the immoveable compaſs, or E. by S.¼E. the true courſe required.

Obſ. 2. *The variation of the compaſs and the true courſe given; to find the courſe by the compaſs.*

Example. *The Variation* 21 *deg. eaſt, and the true courſe I ſhould ſteer is N.E. by E. What courſe muſt I ſteer by the compaſs, to allow the variation.*

1. Place the north in the moveable compaſs to 21 degrees eaſt in the immoveable compaſs.

2. Stretch out the thread over N.E. by E. in the immoveable compaſs, and then in the moveable compaſs, it will lie on 35 degrees, or near N.E. by N. the courſe you muſt ſteer to allow for the variation of the compaſs.

Here I thought to deſcribe the azimuth compaſs, and how to obſerve by it; but conſidering its an inſtrument eaſily underſtood, that diſcourſe may be ſpared.

CHAP. XI. *Of an Obſervation, either of ſun, or ſtar, what it is, how, or with what, and when 'tis taken, and finding the Latitude thereby.*

1. AN Obſervation, is the finding either the ſun's, or ſtar's meridian altitude (at ſea) with a quadrant, or with a croſs ſtaff.

2. Meridian altitude, is the height above the horizon of the ſun or ſtar, they being upon the meridian of the place of obſervation; and that the ſun is every day at noon, but the ſtars at different times, according to the differing of their ſeveral right aſcenſions from the ſun's right aſcenſion.

3. A quadrant is an inſtrument whereby the ſun's altitude (only at ſea) is found.

4. A croſs-ſtaff or fore-ſtaff, is an inſtrument whereby mariners find either the ſun, or ſtar's altitude. The particular deſcription of theſe inſtruments I here omit, having done it largely in the Mariner's Compaſs rectified; to which book I refer the learner, and will now ſhew how to find the latitude after you have obſerved, which is called, working an obſervation, and that in this one propoſition.

Propoſition. *The Meridian Altitude of any heavenly object, and Declination given; to find the latitude of the place of obſervation.*

In this propofition are two cafes.

Cafe 1. *Where, or when the object obferved doth both rife and fet in 24 hours, the rules are thefe.*

Rule 1. The meridian altitude, and declination of one kind; that is, both north, or both fouth; the difference of the zenith diftance, and the declination, is the latitude required.

Note, When the declination is greater than the zenith diftance, the latitude is of the fame name; but if lefs, then of a contrary name to the declination.

Rule 2. The meridian altitude and declination of contrary names; that is, one north, and the other fouth. The fum of the zenith diftance, and the declination, is the latitude required of the fame name with the declination.

Note 1. By meridian altitude fouth, I mean the object obferved is to the fouthward of the obferver; and when north, then to the northward of the obferver.

Note 2. By zenith diftance, underftand the complement of the meridian altitude, of object obferved.

Example 1. On the 20th of May 1731, the fun's meridian altitude 61d. 08m. fouth; and his declination 21d. 54m. north, what is the latitude of the place of obfervation?

	d.	m	
The fun's zenith diftance	28	52	fouth
Sun's declination	21	54	north
The fum (by rule 2) is latitude required.	50	46	north

Example 2. On the 1ft of July 1731, the fun's zenith diftance being 11d. 50m. north, and his declination 22d. 58m. north. What is the latitude of the place of obfervation?

	d.	m.	
From the fun's declination	22	58	north
Subtract the fun's zenith diftance	11	50	north
The remainder is the latitude required	11	08	north

Example 3. On the 3d of June 1731, the fun's zenith diftance being 29d. 15m. fouth, and his declination then 23d. 17m. north. What is the latitude of the place of obfervation?

	d.	m.	fouth
To the fun's zenith diftance	29	15	
Add his declination	23	17	
The fum (by rule 2.) is the latit. required	52	32	north

Example 4. On the 20th of March 1731, the ftar Fomelhaut being obferved, and his zenith diftance 20d. 17m. north, this ftar's declination (in page 164.) is 31d. 19m. fouth. What is the latitude of the place of obfervation?

	d.	m.	
To the ftar's zenith diftance	20	17	north
Add the ftar's declination	31	19	fouth

The

The sum is the latitude required ——— 51 36 south

Example 5. The 30th of March 1731, the foot of the Crosiers (by some called the Cock's Foot) a star much used in southern voyages, being observed, his meridian altitude was 48d. 06m. south; this star's declination (in page 164) is 61d. 15m. south. What is the latitude of the place of observation?

	d. m.
From the Crosiers declination ———	61 15 south
Subtract his zenith distance ———	41 54 south
The remainder is the latitude required. ———	19 21 south

Case 2. *Where or when the object observed doth neither rise nor set in 24 hours; that is, doth not in the diurnal motion, move below or under the horizon.*

Note 1. In some parts of this earthly world, both the sun and stars do not rise nor set, but are above the horizon, and upon the meridian of the same place twice in the space of 24 hours; and this lasteth but for some part of the year with the sun, but always with some stars.

Note 2. Where the sun, or a star, doth neither rise nor set, it cometh upon the meridian below or under the pole; and then its at the least meridian altitude.

Note 3. Some stars in some places come upon the meridian both below and also above the pole; that is between the zenith and the pole; and then it's at the greatest meridian altitude.

Note 4. Where a star cometh upon the meridian both below and also above the pole, it's always to the northward, both its least and greatest meridian altitude, or else always to the southward.

Note 5. Again there are some stars come upon the meridian to the northward, and below the pole; and to the southward between the zenith and the equinoctial; and also to the southward, and below the pole; and to the northward between the zenith and the equinoctial.

Note 6. Where the sun cometh to the meridian below, or a star both above and below the pole, the latitude of that place if of the same name, with the sun, or star's declination: that is, if the sun or star's declination be north, the latitude of the place is north; but south, when the declination is south.

Note 7. For these stars which never come (the sun never doth come) to the meridian above the pole, at their greatest meridian altitude, the former two rules serveth for to find the latitude.

Then to find the latitude of the sun under the pole, or star's both under and above the pole. The rules are these.

Rule 3. The object observed, being on the meridian below the pole the sum of the meridian altitude and complement of the declination, is the latitude required, of the same name with the declination

Rule 4. The object observed, being on the meridian above the pole, the difference of the meridian altitude, and the complement of the declination is the latitude required, of the same name with the declination.

Example 1. August 1st 1731, the sun's meridian altitude below the pole, or under the pole, was found to be 5d. 30m. and his declination 8d. 37m. north; what is the latitude of the place of observation?

	d.	m.	
To the complement of the sun's declination —	81	23	north
Add his meridian altitude below the pole — —	5	30	
The sum (by rule 3.) is the latitude — — —	86	52	north

Example 2. On December the 8th 1731, the Bull's Eye Aldebaran came upon the meridian under the pole, and his meridian altitude was observed to be 9d. 10m. this star's declination (in page 164) is 15d. 50m. north; what is the latitude of the place of observation?

	d.	m.	
To the complement Bull's Eye declination —	74	10	north
Add his meridian altitude under the pole — —	09	10	
The sum (by rule 3.) is the latitude	83	20	north

Example 3. On June the 25th 1731, the foot of the Crosiers was observed under the pole, its meridian altitude 21d. 25m. the declination of this star (in page 164.) is 61d. 15m. south: I demand the latitude of the place of observation?

	d.	m.	
To the complement of the star's declination	29	45	south
Add his meridian altitude — — —	21	25	
The sum (by rule 3.) is the latitude — —	51	10	south

Example 4. The 17th of February 1731, the Northern pointer of the Great Bear came to the meridian above the pole, and his meridian altitude was 56d. 10m. this star's declination is 63d. 30m. north: what is the latitude of the place of the observer?

	d.	m.	
From the star's meridian altitude above the pole	56	10	
Subtract the complement of his declination	26	30	north
Remainder (by rule 4.) is the latitude — —	29	40	north

Chap. XII. *A sea-reckoning, or journal, what it is, and the manner how it's kept, directions to correct it, with an example, and the explanation thereof.*

THE keeping a good Reckoning or Journal, is not only the Mariner's reputation, but (under God) the preservation of a ship, and all in it; the ignorance thereof has been, (if not the only, I may say) the chief cause of loosing divers rich

rich ſhips, and many dear lives, and thence the impoveriſhing of ſeveral families.

Then certainly, it ſhould be their great concern, to be expert herein, who take on them the navigating Ships to remote places, when ſo great a truſt as men's lives and eſtates, are repoſed in them, that ſo, by a knowledge of, and a conſtant careful practice, in keeping an exact Journal, they may not only bear the empty name of Navigator, but thereby prove themſelves deſervedly worthy of the title of Compleat Artiſts.

And for a compleat keeping a Journal, I prefer this method hereafter following; which, tho' it be new, and uſed (as I know of) but by few, yet I doubt, when better known it will be more uſed: now that you may rightly underſtand what it is, and how to keep an account of the ſhip's way by this new form, I will thus explain it.

1. Know that a Journal, or ſea-reckoning, is a punctual writing down every day in a book (fit for that purpoſe) the courſe, diſtance, difference of latitude and departure, the ſhip hath made, what latitude and longitude ſhe is in; and alſo the wind, weather, with all accidents and occurrences that happen.

To perform which after the beſt manner, do theſe preparative things.

Firſt, Provide a folio Book of 2, 3, or 4 quire of demy-paper, and let it be ruled like the Log-Board, (in page 62) with 5 columns, taking up about half the breadth of each page.

Theſe five columns may be marked or noted at the head of each column, with letters thus;

H	which ſtandeth for	Hours under it are the hours of the day,
K		Knots, } run out that day.
F		Fathoms, } run out that day.
C		Courſes, which have been ſteered that day,
W		Winds, which have blown that day, &c.

Secondly, Rule 12 lines croſs the foreſaid 5 columns, and ſo far aſunder, that on occaſion you may write two lines of writing in the ſpaces between thoſe lines; then will the ſame ruling ſerve for an Eaſt-India Voyage, in which the Log is heaved out every hour, and alſo for other voyages where it's uſed every two hours.

Thirdly, In the firſt column (marked at the upper end with H, write down the hours of the day; that is for common voyages, 2, 4, 6, 8, 10, 12, and 2, 4, 6, 8, 10, and 12: but for an Eaſt-India voyage, 1, 2, 3, &c. to 12 at midnight; then 1, 2, 3, &c. to 12 at noon. And thus far is the book fitted, and prepared to copy off the Log-Board.

Fourthly, Under these 5 columns let there be ruled 12 short columns, which may take up the whole breadth of the page of the book. These may be entitled as in the journal following this discourse, (in pages 252 and 253) and needs not any further explanation.

Now such a book so ruled as here expressed, each page thereof will contain two days sailing, with all appertaining thereunto as shall afterwards appear.

Fifthly, Having a Journal Book, thus prepared, and now on your departing, the first thing is to enter the title of the Journal, which may be done thus: in the top or head of the first page of the Journal Book write the title thereof in words after the form immediately before the Journal in page 251.

And now the book is compleatly prepared, fit for the use intended, and that's keeping a Sea reckoning, after this manner.

2. Next under, or after the title, (write in the blank space between the 5th column for the wind, and the side of the book) the Year, Month, Day and Hour, you part with sight of the land, and also the circumstances and actions attending the same, &c. as here you may see in the two first sides of the Journal: which by reason of the smallness of this book reacheth pages 252 and 253, which are to be esteemed but as one page or side of the Journal.

3. Every day at noon, write in the 5 columns the same you find written in the Log-Board, which containeth the Ship's Course steered, Distances run by the Log, what winds have blown, what Sails handed, and when.

4. In the vacant space of the right-hand of these 5 columns (which takes up more than half the breadth of the book) express the transactions of the day, as Winds, Weather, Currents, setting of the Sea, handling of Sails, meeting or parting with Ships, death of Men, variation of the compass, and all other Accidents and Occurrences whatsoever.

5. Then correct the several courses, by allowing for Leeward-way, Currents and Variation, according to the nature of them; and bring them into one course (by chapter 3. section 4. of plain Sailing, in page 61.) by which you will find the ship's Distance, difference of Latitude, and departure from the meridian; which being set down in the columns bearing those titles, then (by chapter 3. section 3. general rule 3. in page 55.) find the Latitude the ship is in, and set that in its proper column: and lastly, (by chapter 4. section 3. problem 5. in pages 91 and 92. Also chapter 4. section 2. problem 5. page 86, of Mercator's Sailing) find the longitude the ship is in, and place that in the 12th and last column; and thus you finish that day's work.

For Leeward, or Leeway, the allowances are such as in these 8 cases following.

First,

First, The ſhip being upon a wind, allow one point for Leeway.

Secondly, The wind blowing hard to cauſe one Top-ſail to be taken in ; allow two points for Leeway.

Thirdly, When it blows ſo hard that both Top-ſails are taken in, and the ſea runs high ; allow then three points for Leeway.

Fourthly, the Fore-ſail being furled, and the ſhip try under a Main-ſail and a Miſſon ; allow four points for Leeway ; for ſhe then makes her way about four points before the Beam (as the ſea phraſe is.)

Fifthly, When the ſhip trys under a Main-ſail only, ſhe then makes her way near three points before the Beam ; that is near five points for Leeway.

Sixthly, If the ſhip trys under a Miſſon only, her way is about two points before the Beam ; that is, allow ſix points for Leeway.

Seventhly, When ſhe lies a Hull ; that is, with all her ſails furled, her way is one point before the Beam, and then ſeven points in her Leeway.

Eighthly, If the wind hath blown hard at W S W. and made the ſea run high, the ſhip ſtemming ſouth, and the wind ſhifting to ESE. then whilſt the ſea continues to run high, it ſtrikes the ſhip on the Lee-Bow, and abates the Leeway.

Note, In all thoſe eight caſes, reſpect muſt be had to the ſmoothneſs of the water, or the ſea's running high, and then the allowances may be rectified with the greater certainty, by ſetting the ſhip's wake by the quarter of the compaſs, placed on each rail of the ſhip's quarter, which is uſually ſet there for that purpoſe.

Theſe directions, with a conſideration of the ſhip's Trim, Sail aboard, ſtreſs of Wind, and growth of the ſea, being put into practice, will ſo improve the Young Navigator's judgment, that he'll ſeldom fail of making a true allowance for the ſhip's leeway.

6. After this manner are you to proceed every day from noon to noon, which is the beginning and ending of the day aſtronomical, the day by which the Mariners keep their ſea-reckoning.

7. Remembring always to obſerve for the latitude, when opportunity preſents, either by ſea or ſtars ; that being the chief thing to be depended on, and by which the reckoning is confirmed or rectified, which is the next thing to be treated of.

8. When the latitude by account agrees with the latitude by obſervation, then is the reckoning confirmed, and you are ſure its kept well.

9. But if they diſagree, then either the ſhip hath out-run your reckoning, or your reckoning hath out-run the ſhip ; and there is ſome error, either in the courſe, diſtance failed, or both of

 them ;

them; now to find where the error lies consider whether there be a current, or no,

10. If there be a current, try it, and find which way it sets, and how fast; and by that correct both course and distance; and if that makes the reckoning Latitude to agree with the observed Latitude, you have then truly corrected the reckoning.

But if you, only by some probable reason conjecture there is a Current, then give what allowance you think meet to the difference of Latitude, and departure, and see if that will reform your reckoning latitude, that it agree with the observed latitude; if so you have guessed well (for you must ever keep to the Latitude by Observation that being the principal thing to be relied upon) but if it will not agree with the observed Latitude, it's to be supposed that there are mistakes in your Conjecture, or some other cause of this error in the reckoning.

11. When there's no Current, nor any Variation, or if there be either or both; and they are allowed for according to art and reason, and yet they will not agree with the observed Latitude; then there is an Error either in Steerage, or in the Log, and to know in which it is, take this

General rule.

Differ. of latitude } the greater, the Error is in the } Log.
Departure— — } the greater, the Error is in the } Course.

12. When there is an Error in the course steered, you must (after the allowance in the 10th and 11th rules have been made) then only correct the difference of latitude and so make the reckoning latitude to agree with the latitude by observation, and the work is done.

13. But when the error lieth in the log, the distance is faulty, and this is that which most usually makes the difference between the observed latitude, and the latitude reckoning. And herein are two cases.

Case 1. *In north latitude sailing towards the north, and in south latitude, sailing towards the south.*

If the observed latitude be the greater, then hath the ship outrun the reckoning; but if it be the lesser, the reckoning hath out-run the ship.

Case 2. *In north latitude, sailing towards the south, and in south latitude, sailing towards the north.*

If the observed latitude be greater, then hath the reckoning out-run the ship; but if it be the lesser, the ship hath out-run the reckoning.

14. When the ship hath out-run the reckoning, then is the reckoning too little, and the difference between the observed latitude and reckoning latitude, must be added to the north or south Column in the reckoning; and so doing it's corrected.

15. But

15. But when the reckoning hath out-run the ſhip, then is the reckoning too great, and the difference between the obſerved latitude and reckoning latitude, muſt be ſubtracted from the north or ſouth columns in the reckoning; and ſo doing its corrected.

16. To correct the departure (the eaſt, or weſt column in the reckoning) when the error is in the diſtance do thus: add up the N, S, E, and weſt columns from the beginning, if it be the firſt error; otherwiſe from the laſt error, or from the laſt obſervation to the day of the preſent error; in order to find the difference of latitude and departure; as was ſhewed in adding up the columns in a traverſe.

And then the proportion to find the error or correction in the departure, is thus;

As the difference of latitude, is to the departure;

So is the correction in latitude to the correction in departure.

Note, Correction in latitude is the difference between the obſerved latitude, and reckoning latitude.

The correction in departure muſt be added to, or ſubtracted from the eaſt or weſt column in the reckoning, according to the 14th and 15th rule aforeſaid; and ſo the departure will be corrected.

17. To correct the longitude do thus; find (by the Table of Meridional Parts) the meridional difference of latitude, between the obſerved latitude, and the reckoning latitude, and then the proportion is this:

As the correction in latitude is to the correction in departure:

So is the meridional difference of latitude, to the correction in longitude.

Then according to the new way of computation of longitude in the Mariner's Compaſs rectified, if the longitude, and its correction be both eaſt, or both weſt, add; but one eaſt, and the other weſt, ſubtract, and the longitude is corrected.

And having gone over the rules, and directions about keeping, and correcting a Sea Reckoning, or Journal, I will alſo give an example of a Journal, of an intended Voyage from the Lizard towards Barbadoes; that the foregoing rules may be the better underſtood.

And altho' this following Journal be but an example of ſeven days, being ſo deſigned that this book might not ſwell too big (yet it may be of ſufficient intelligence to a diligent reader) for the right underſtanding this method of Keeping, and correcting a Sea Journal, eſpecially if the following explanation be deliberately compared with the preceding directions; and thereby as informing, as if the whole ſeries of the voyage had been inſerted, which would have both augmented the book, and its price, but not anſwerable to the underſtanding it.

Having

Having been treating about keeping and correcting a Journal, which cannot be well done 'till the error in the Log-Line and Half-Minute-Glafs be rectified; I think it neceffary here to fay fomething of both.

The manner of keeping a reckoning or Sea Journal (by our Englifh Navigators) is by the Log-Line, and Half-Minute-Glafs; ought not care to be taken that they be true, elfe a reckoning kept by them cannot be true?

But it hath been an ancient cuftom, and ftill is too much ufed to meafure 7 fathom, or 42 feet, between knot and knot on the Log-Line, which is grounded on this conjecture, that 5 feet make a pace, a 1000 (fuch) paces a mile, and 60 (fuch miles) make a degree; that is a degree contains 300000 feet, and a mile (or minute) 5000 feet, and becaufe an Half-Minute of time is the 120th part of an hour, and the 120th part of a mile 5000 feet, is almoft 42 feet, the meafure commonly put between each knot on the log-line.

But this erroneous computation hath been fufficiently contradicted by Mr. Oughtred, Mr. Norwood, and others.

Mr. Oughtred, in his Circles of Proportion, in page 153 doth allow 66¼ ftatute miles to a degree on the earth, each mile being 5280 feet, fo that in a degree there are 349,800 feet.

And Mr. Richard Norwood in his Seaman's Practice, page 43. doth prove a degree on the earth, to contain 367200 Englifh feet; but at length confents to allow 360000 feet to a degree, and fo 6000 feet the 60th part, to be one minute, commonly called a mile; fo that 6000 feet fhould be the number from whence the knots on the log-line, ought to be deduced.

Therefore, if 6000 (the feet in a mile or minute) be divided by 120 (the half minutes in one hour) the quotient is 50 feet; for the diftance of each knot on the log-line, and 25 feet is half a knot.

Now 5 being the one tenth of 50, let each fathom on the log-line contain 5 feet; and then 5 of thefe fathoms make a half knot, and 10 of them one knot.

And according to thefe meafures, let every man that would keep a true reckoning, and give a good account of his voyage, be perfuaded to mark his log-line, and not let cuftom prevail above reafon.

Then it follows, that if a fhip runneth out one of thefe knots in half a minute, fhe runneth one mile or minute, the 60th part of a degree in an hour; if 2 knots, then 2 miles; if 3 knots and 4 fathoms, then miles 3, 4; that is 3 miles and 4-tenths of a mile in an hour, and fo for any other. And by fuch a log-line is the following reckoning kept.

The like regard muft be had, that the half-minute-glafs be of a juft length, otherwife no true account of the fhip's way

can be kept: now for that, take an approved experiment, mentioned by Mr. Philips, in his Advancement of Navigation, The second part, Page 9. as follows.

An easy and exact way to measure a *Half Minute Glass*.

Let a Plummet of any form or weight be fastened to one end of a Thread, or Silk-string, that is 38½ inches long, and at the other end is a loop or noose, to hang it on a small pin or nail, fastened in any place, so that the plummet may swing freely.

Then the loop of the String being hung on the pin, the String 38½ inches from the center of gravity to the center of motion; this is 38½ inches from the end of the loop to the middle of the Plummet; and the Plummet caused to swing; each of those Swings shall be a true second of time, and 30 of them the just length of an Half-Minute-Glass.

Always counting the Swings both forward from, and backward to the perpendicular, supposed to fall from the pin whereon the string doth hang: for half a second of time is measured every time the plummet passeth from the perpendicular, to it's utmost swing either ways.

But when the ship hath any considerable motion, make the string 7 inches shorter, and there make a knot to hold it by, between your finger and thumb; then by the motion of the hand, cause the plummet to ascend to an angle of about 60 degrees, every swing from the foresaid perpendicular; then each swing shall be equal to those before-mentioned; so that by this experiment, you may measure a true Half Minute of Time, without a Glass, and by it examine the truth of any Glass.

A Journal of a VOYAGE,

(By God's Permission) in the

George of LONDON. *A. B.* Commander.

FROM THE

{ Latitude 50d. 00m. North.
{ Longitude 5d. 24m. West.

TO THE

Island Barbadoes in { Latitude 13d. 25m. North.
{ Longitude 58d. 04m. North.

Their difference of longitude 52d. 40m. West.

The course from the Lizard, South 40d. 55m. West.

Their distance in that rhomb, 3407 Minutes.

Kept by *C. D.* chief mate.

Began January ☉ 16th. 1732.

After-

	H	K	F of 5 feet	C	Wind and Weather.
Afternoon.	2	5	2	W by N	NNE.
	4	5	—	W S W	N *Silly* N by W 7 Leag. off.
	6	5	6		NNE.
	8	5	5		
	10	5	5	S W by W	NW by N Rain
	12	6	5	W S W	North Rain
After Midnight.	2	6	1		N by E
	4	6	1		
	6	6	3		NE. by N. Rain
	8	6		SW by W	
	10	6		W S W	
	12	6			ENE.
Sum is	79		8		Which doubled (is Min. 159.6

Month Days.	Week Days.	Month and Year.	Course	Distance sailed in Minutes.	Diff. of Lat. in Min. N	S
16	☽	Jan 1732	S	18		m. 18.0
17	♂		W S W	137		91.5

The

☽ The 16 of January, 1732. At noon we ſaw the Lizard point bear north about 18 minutes or miles diſtance of us: we have variable winds, freſh gales, cloſe hazy rainy weather, as *per* Columns.

In company with the Succeſs, capt. E. F. commander bound for the Eaſt-Indies.

♂ 17th our Courſe and Diſtance made good this day, I make WSW. 137 minutes, with latitude, meridional diſtance, and longitude: as *per* Columns underneath.

		d. m.	
Zenith Diſtance	——	Magnet Amplitude.——	27 30 ES.
Declination	——————	True Amplitude.———	39 55 ES.
Lat. by Obſervation	— —	Variation. — —	—12 25 W.

Depart. in Min. E.	W.	Latitude by Account in deg. and min.	Meridional Diſtance deg. and min.	Longitude by Account in deg. and min.
		49. 42 North		05. 24 W.
	m127.3	48. 51 North	02. 07 W.	08. 37 W.

After-

	H	K	F of 5 feet	C	Wind and Weather.
Afternoon.	2	6	—	W S W	NE Rain and Snow
	4	6	—	S W	
	6	5	8		Rain and Snow.
	8	7	1	SW by W	NE by E Rain
	10	7	—	W S W	ENE Rain
	12	7	1		NE by N Rain
After Midnight.	2	7	—		NE Lightning.
	4	6	8	SW by W	NE by E
	6	7	2	W S W	NE
	8	7	—		ENE Hail and Rain
	10	6	2		Rain
	12	6	6		E Rain

Sum is 79——8——Which doubled (is min. 159.6.

Month Days.	Week Days.	Month and Year.	Course.	Distance sailed in Minutes	Diff. of Lat. in Min. N	S
18	☽	Jan. 1732	swbw½w	158		73.6

‡ The

♂ The 18th of January 1732, hard Gales of variable winds, with some snow, hail and rain.

Our top-sails reefed, and so have been ever since we saw the Lizard. A great swelling sea following us, and setting towards the SSW.

Our course and distance I judge to be SW by W. ½ west 158 minutes, with latitude, meridional distance and longitude as in the Columns underneath.

	d. m.		d. m.
Zenith Distance	— —	Magnet Ampl.	—
Declination	— —	True Ampl.	—
Lat. by Observation	—	Variation	—

Depart. in Min E	Depart. in Min W	Latitude by Account in deg. and min.	Meridional Distance in deg. and Min.	Longitude by Account in deg. and min.
	m139.8	47. 37 North	04. 27 W.	12. 10 W.

After

	H	K	F of 5 feet	C	Wind and Weather
Afternoon.	2	6	3	W by W	E. Hail and Rain.
	4	7	3	S. W.	Handed Fore-Top-Sail. Rain
	6	8			NE. Rain
	8	7	6		
	10	8	2		
	12	8			
After Midnight.	2	8			
	4	8			
	6	8			Rain.
	8	8	1		Handed Main-Top-Sail. Rain.
	10	6	7		
	12	6	2		

Sum'd up 90--4 Which doubled (is Min. 180.8

Month Day.	Month ays.	Week	Month and Year.	Course	Distance sailed in Minutes	Diff. of Lat. in Min. N.	S.
19	♑		Jan. 1732. 45d. 07m.	S.W	181		125 29
							240
			Corrections by Observation Corrected.				149.9.

The

‡ The 19th of January, 1732, was bad weather, very hard gales, thick air, with some hail and rain.

A great sea after us, setting towards the SSW. for these three days past.

By observation the ship hath out-run the reckoning 24 minutes south, which being attributed to the SSW. sea, our course and distance corrected is SW. by ¾ W. 204 minutes; with meridional distance, and longitude; as underneath.

	d. m.		d. m.
Zenith Distance	62 55 S.	Magnet. ampl.	37 00 W. S.
Sun's declination	17 48 S.	True amplit.	24 50 W. S.
Lat. by observa.	45 07 N.	Variation — —	12 10 W.

Depart. in min. E.	Depart. in min. W.	Latitude by account in deg. and min.	Meridional distance in deg. and min.	Longitude by account in deg. and min.
	1.294	45. 31 N.	06.36 W.	15.19 W.
	99	00.24 S	00.10 W.	00.14 W.
	139.3	45.07 N.	06.46 W.	15.33 W.

	H	K	F of 5 feet	C	Wind and Weather
Afternoon.	2	5	7	W by S	NE.
	4	7			Set main top-sail
	6	6	1		NE by N.
	8	5			
	10	5	2	SW by W	NE.
	12	4	3	W S	NE Rain
After Midnight.	2	5	5		N Rain
	4	6	3		NW by N Set fore top-sail
	6	6	1		
	8	6	2	SWbS½w	N
	10	6			NNE
	12	6			

Sum'd is 69——6—Which doubled (is min. 138.8 Tenths.

Days Month	Days Week	Month and Year.	Course.	Distance sailed in Minutes	Diff. of Lat. in Min. N	S
29	♃	Jan. 1732	S w bs ½w	138		104.2

☿ The 20th of January, 1732, close weather, with some rain, fresh gales, and variable; with a NNE sea.

About 8 this morning we saw a sail on our larboard quarter so far off that we could but just discern her.

Our course and distance made good this 24 hours in S 41d' W. or SW by S ½ W. 138 minutes, with latitude, meridional distance, and longitude: as here under,

	d. m.			d. m.	
Zenith Distance	—	Magnet Amplitude	—	35 25	ES.
Declination	—	— True Amplitude	—	23 30	ES.
Lat. by Observation	—	Variation —	—	11 55	W.

Depart. in Min.		Latitude by Account in deg. and min.	Meridional Distance deg. and min.	Longitude by Account in deg. and min.
E.	W.			
	90.4	43.23 North	08. 16 West	17, 39 West.

	H	K	F of 5 feet	C	Wind and Weather.
Afternoon.	2	5	3	SSW	NNE
	4	5			
	6	4	3		N by E
	8	5	3		Rain
	10	6	2		Rain
	12	5	5		
After Midnight.	2	5			N by W Rain
	4	5			Rain
	6	5	3		Rain
	8	5			
	10	5	3		
	12	4	8		

Sum'd is 62 ——o Which doubled (is min. 124.

Month Days.	Week Days.	Month and year	Course	Distance sailed in minutes.	Diff. of lat in min. N	S
21	♄	Jan 1732	S S W	124		114.6

♃ The

♃ The 21ſt of January 1732, clear weather, intermixt with ſmall ſhowers of rain, freſh gales, and a NNE. ſea.

About 6 this morning we ſaw two ſails on our larboard-bow, which we judged were Turks men of war, who chaſed us till ſun ſet, and could not get upon us; then they lay by, ſo we loſt ſight of them.

Our courſe is SSW. 124 minutes with latitude, meridional diſtance, and longitude: as here under.

	d. m.		d. m.
Zenith Diſtance	———	Magnet Amplitude.	———
Declination	———	True Amplitude.	———
Lat. by Obſervation	———	Variation.	

Depart. in min. E.	Depart. in min. W.	Latitude by Account in deg. and min.	Meridional Diſtance in deg. and min.	Longitude by Account in deg. and min.
	47.4	41.28 North	09.03 W.	18. 44 W.

	H	K	F of 5 feet	C	Wind and Weather.
Afternoon	2	4	3	S	N.
	4	4	2		Split main top-sail Brought another to.
	6	5			
	8	5	2		NNE.
	10	5	6		Rain
	12	5	7		N by E.
After Midnight.	2	5	5		Rain
	4	4	7		NNE. Rain
	6	5	3		
	8	6	1		NE by N.
	10	6	5		
	12	6	6		

Sum'd is 64——7——Which doubled (is Min. 129.4

Month Days.	Week Days.	Month and Year.	Course	Distance sailed in Minutes.	Diff. of Lat. in Min. N	Diff. of Lat. in Min. S
22	♄	Jan 1732	South	129		129.4

♄ The

♄ The 22d of January, 1732. fresh gales, uncertain weather, and a NNE sea after us.

Yesterday about three in the afternoon letting the reef out of the main top-sail, it split, which we unbent, and brought another to immediately.

Our course is south 129 minutes, with latitude, meridional distance, and longitude: as here under.

	d. m.		d. m.
Zenith Distance — —		Magnet Ampli.	
Declination — —		True Ampli.	
Lat. by Observation —		Variation	

Depart. in min. E	Depart. in min. W	Latitude by Account in deg. and min.	Meridional Distance in deg. and min.	Longitude by Account in deg. and min.
		39. 19 N.	09. 03 W.	18. 44 W.

	H	K	F of 5 feet	C	Wind and Weather
Afternoon.	2	6	1	S	NNE.
	4	6	3		
	6	7			
	8	6	2		Rain
	10	6	5		ENE.
	12	6	2		NE by N Rain
After Midnight.	2	5	3		ENE Rain
	4	6			EN and N by W
	6	5			N by E and ENE Rain
	8	5	5		
	10	5	8		
	12	5	7		NE by N

Sum'd is 71–6 Which doubled (is Min. 143.2 Tenths.

Month Days.	Week Days.	Month and Year.	Course	Distance sailed in Minutes	Diff. of Lat. in Min. N.	S.
19	♃	Jan. 1732. 36. 22.	S	143		143.2
		Corrections by Observation				34.0
		Corrected.				177.2

The

☽ The 23d of January, 1732. fresh gales with small showers of rain, a great sea from the NNE.

Since the 19th instant (the last day of observation) to this day I find we are more southerly 34 minutes than by account; and (with respect to the NNE sea) more westerly 14 minutes in meridional distance, which makes 17 minutes in longitude.

Our course and distance corrected by a good observation in S. 4d. 35m. W. or S ½ W. 178 minutes, with latitude, meridional distances, and longitude as here under.

	d. m.		d. m.
Zenith distance	53.02 S.	Magnet. amplitude —	17.40 WS
Sun's declinat.	16.40 S.	True amplitude — —	31.00 WS.
Lat. by obs. —	36.22. N.	Variation — — — —	13.20 W

Depart. in min. E.	Depart. in min. W	Latitude by account in deg. and min.	Meridional Distance in deg. and min.	Longitude by account in deg. and min.
		36.56 North	09.03 W.	18.44 W.
	14.1	00.34 S	00.14 W.	00.17 W.
	14.1	36.22 N.	09.17 W.	19.01 W.

The

The explanation of the preceding Journal.

IN this Journal in the upper part repreſenting the log-book, there are five columns, and in the lower part there are twelve columns; all which have been deſcribed in the directions immediately before the Journal (in page 245). The buſineſs now is to explain the manner of proceeding in this Journal, and that is thus: the firſt page of the Journal (in page 252) contains the log-board for the firſt day after our departing the Lizard, which was ☉ the 16th of January 1732, at noon, the Lizard bore N. 18 minutes, diſtance, &c. as in the Journal (page 252) you may ſee.

Sunday	☉
Monday	☽
Tueſday	♂
Wedneſday	☿
Turſday	♃
Friday	♀
Saturday.	♄

But becauſe the week day is expreſſed by a character, which may not be underſtood by every one, (tho' its convenient ſo to write them) you have here the week days with their characters.

And becauſe the Lizard did bear north 18 minutes diſtance, therefore make the courſe ſouth, and place 18m. in the column, under diſtance, &c. then the difference of latitude is m. which accordingly place in the ſouth column, and ſubtract it from the Lizard lat. 50d. 00m. the remainder 49d. 42m. is the lat. the ſhip is in, at parting ſight of land; which accordingly is placed in the column under the lat. by account, &c. And in the laſt column, becauſe the courſe is ſouth, place the longitude of the Lizard 5d. 24m. weſt, and all that day is done.

Then from the 16th day at noon, to the 17th day at noon, you have the courſes and diſtances for every two hours; with the wind and weather, as they are taken from the log-board; as all other circumſtances attending, are there expreſſed; for the particulars whereof, I refer to the Journal it ſelf, in page 252. The ſeveral courſes and diſtances of this day, may be reduced to three courſes: thus, the work of ☽ the 17th of January 1732, being the firſt days ſailing in the preceding journal, to page 252.

H	K	F
Firſt 4 W S W	5	—
6 The ſame	5	6
8 The ſame	5	5
12 The ſame	6	5
2 The ſame	6	1
4 The ſame	6	1
6 The ſame	6	3
10 The ſame	6	
12 The ſame	6	—
Summed up is	53	1
That is WSW.	106	2

H.	K	F
Secondly, 2 W by N	5	2
That is W by N	10	4
Thirdly, 10 SW by W	5	5
8 The ſame	6	5
Summed up is	11	5
That is SW by W 23 min.		

Courſes	Diſt.	N	S	E	W
W S W	106. 2	—	40. 6	—	98.1
W by N	10. 4	20			10.2
SW by W	23. 0		12. 8		19.1
Diſtance	139. 6		53. 4	dep. 127.4	
			20		

Difference of latitude 51.4

As

As diff. lat... dep. :: radius .. T. course.
As m. 5. 1.$\frac{4}{10}$ m. 127.$\frac{4}{10}$ :: T. 45d. .. T. 68d. om. (S. Wly,) or WSW
Then, as sine course .. depart. :: radius distance.
As S. 68d. 00m. .. m. 127.4 :: S. 90d. .. m. 137.4.

So that the course made good, is S. 68d. 00m. westerly or W S W. nearest, and the distance 137 min. 4 tenths; which place in their proper columns, as may be seen in the first day of the Journal, at the foot thereof in pag 252.

The difference of latitude m. 51 $\frac{4}{10}$ (or nearest 51 minutes) being southerly subtract from 49d. 42m. the latitude at parting sight of the land, the remainder 48d. 51m. place under latitude by account, for the latitude the ship is now in.

Again. The departure 127 $\frac{4}{10}$ minutes being reduced to degrees maketh 2d. 07m. westerly, which place in the column under meridional distance, &c. in page 253.

Lastly, To find the longitude the ship is now in, you have both latitudes 49d. 42m. and 48d. 51m. the present latitude, and the latitude of the day before, with the departure min. 127.4, by which is found the difference of longitude according to chapter 4. section 4. problem 5. of Mercator's sailing in pages 90, and 91. where the proportion is thus:

As the difference of latitude is to the departure; so is the meridional difference of latitude to the difference of longitude.

		d. m.		min.	
☉ 16	lat.	49 42	merid. parts	3447	found in the table
☽ 17		48 51		3369	of meridional pts.

The meridional difference of latitude 78. Then say,
As 51m.$\frac{4}{10}$ .. m. 127.$\frac{4}{10}$ :: m. 78 .. 193m. or 3d. 13m. westerly, which being added to the longitude of the day before 5d. 24m. the sum 8d. 37m. W. is the present longitude, which place in the last column of that Journal: then the day's work is finished.

Then, from the 17th day at noon, to the 18th day at noon, (in the two next pages of the Journal) the courses and distances for every two hours; the wind and weather with other circumstances attending, taken from the Log-Board, are set down; for the particulars, see the Journal in pages 254 and 255.

Now the several courses and distances of this day are reduced thus:

The work of ♂ the 18th of January 1732, the second day's sailing in the preceding journal in pages 254 and 256.

First,

	H	W S W.	K	E.
Firſt,	2	The ſame	6	
	10	———	7	—
	12	———	7	1
	2	———	7	—
	6	———	7	2
	8	———	7	
		———		
	10	———	6	2
	12	———	6	6
Summed up is			54	1
That is WSW.			108	2

	H.		K	F.
Secondly,	4	S W.	6	—
	6	The ſame	5	8
Summed up, is —			11.	8
That is S. W. —			23	6
Thirdly,	8	SW by W.	7	1
	4	The ſame	6	8
Summed up, is —			13.	9
That is S W by W.—			27	.8

So that the courſes of this day are theſe. WSW.m. 108.2. SW. m. 23.6 SW by W. m. 27.8, and by chapter 3. ſection 4. of plain ſailing, in pages 64 and 65, may be reduced into one courſe as followeth.

Courſes	Diſt.	N.	S.	E.	W.
W S W	108.2		41.5		100.0
S W	23.6		16.7		16.7
SW by W	27.8		15.4		2.31
Diſtance	159.0	Lat.	73.6	Dep.	139.8

As diff. lat. ·· dep. :: radius ·· T. courſe.
As m. 73.6. ·· m. 139.8 :: T. 45d. ·· T. 62d. 15m. ſouth weſterly, or SW by W$\frac{1}{2}$W.
As S. courſe · departure :: radius ·· diſtance.
As 62d, 15m. ·· m. 139.8 :: S. 90d. ·· 158. minutes.

The difference of latitude is m. 73.6S. and the depart. m. 139.8 weſt, makes the courſe S. 62d. 15m. W. or SW by W. $\frac{1}{2}$ W. and the diſtance 158 minutes; which place in their reſpective columns in the Journal of the day propoſed, in page 254 and 255.

Then the difference of latitude m. 73.6 or 1d. 14m. being ſubtracted from the latitude the day be fore, 48d. 51m. the remainder 47d. 37m. place under latitude by account, for the latitude the ſhip is now in, ſee page 255.

And the departure m. 139.8 near 140 minutes, or 2d. 20m. being added to (becauſe it's weſt, had it being eaſt it ſhould have been ſubtracted from) 2d. 07m. the meridional diſtance the day before, and it makes 4d. 27m. weſt, for the ſhip's whole meridional diſtance from the Lizard; which place under it's proper title, in page 255.

Laſtly, To find the longitude the ſhip is now in, you have the latitudes 48d. 51m and 47d. 37m. the preſent latitude, and latitude of the day before, with the departure m. 139.8, by which you may find the difference of longitude in this manner.

		d. m.		d. m.	
☽ 17.	lat.	48.51	mer. parts	3369	found in the table of
♂ 18.		47.37		3257	meridional parts.

The meridional differ. of latitude 112. And then say,

As m. 736. ·· 139.8 :: 112m. ·· m. 213 or 3d. 33m. westerly, which being added to the longitude of the day before, 8d. 37m. the sum 12d. 10m. west is the present longitude, which place in the last column of the Journal in page 255; and the second day's work is finished.

Again. In the two next pages of the Journal, is the courses, distances, winds, &c. taken off the log-board from the 18th day at noon, to the 19th, which are wrought as follows.

The works of ☿ *the 19th of January* 1732, *the third days sailing in the preceding journal.*

Courses.	Dist.	N	S	E	W
SWbyW.	12.6		7.0		10.5
S W	168.2		118.9		118.9
Distance	180.8	diff. lat.	125.9	dep.	129.5

As diff. lat. ·· departure :: radius ·· T. course.

As m. 25.9 ·· m. 129.4 :: T. 45d. ·· T. 45d. 47m. south or S W is the course.

As S. course ·· departure :: radius ·· distance.

As S. 45d. 47m. ·· m. 129.4 :: S. 90d. ·· 180.5 minutes.

By the work above it's evident, that the difference of latitude is m. 125.9 south, the departure m. 129.4 west, which makes the course S. 45d. 47m. W or S W. and the distance 181 minutes, which place in the respective columns, in the Journal for ♀ the 19th of January, in pages of 256 and 257.

Then the difference of latitude m. 125.9 or near 126 minutes is 2d. 06 m. south, which subtract from the latitude of the day before, 47d. 37m. remainder is the latitude by account, the ship is now in 45d. 31m. N. which place in the 10th column, in page 279.

And the departure 129m. or 2d. 9m. west being added to 4d. 27m. the meridional distance of the day before, makes 6d. 36m. west, the whole meridional distance by account from the Lizard, which place in the 11th column of the Journal, in page 256.

And now having both latitudes 47d. 37m. and 45d. 31m. with the departure m. 129.4; by them find the difference of longitude, thus,

♂ 18	lat.	47d. 37m.	mer. parts	3257 m.	found in the
♀ 19		45d. 31m.		3074 m.	table of mer. parts.

The meridional difference of latitude 183 min.

As

As m. 125.9 ·· m. 129.4 :: 183m. ·· 189m. or 5d. 09m. west is the difference of longitude, and being added to the longitude of the day before, 12d. 10m. the sum 15d. 19m. is the longitude (by account) the ship is now in; which place in the last column of the Journal, in page 279: and this day's work (as to the account of dead reckoning) is finished.

But on the said 19th of January at noon, by a good observation of the sun, I find the latitude 45d. 07m. N. whereas by the reckoning or Journal, the latitude is 45d. 31m. north, their difference is 24m south, that is, the ship by observation is 24m. more southerly than by the reckoning.

Wherefore to correct the latitude, place 24m. in the south column, and add it to the difference of latitude m. 125.9 it makes min. 149.9 for the correct difference of latitude: also subtract it from 45d. 31m. (the latitude by account) to make it agree with the observation, as you see it done in the Journal for the said 19 th day, in page 256 and 257.

Then to correct the departure, consider, according to the 9th rule in the directions for keeping a Journal, preceding it in page 269, whether there be a current or no, and consulting the written Journal, I find, "A great sea after us setting towards the S S W. for these three days past; which I take to be the cause of this error of 24m. in the reckoning latitude. And therefore (by chap. 3. sect. 3. prob. 2. of plain sailing) find what departure a SSW. course, with difference of latitude 24m. will make, which is thus,

As S. 6 points ·· 24m. :: S. 2. points ·· m. 9.9. the correction in the departure, which place in the west column and add it to the departure m. 129.4 it makes m. 139.3, for the corrected departure; also add it to 6d. 36m. (the meridional distance by account) it makes 6d. 46m. the corrected meridional distance as you see in the 11 th column of the Journal in page 257. And to correct the longitude by the 17th rule for keeping a Journal (in pages 249 and 250) is thus:

		d. m.		min.	
Lat. by	account	45.31	mer. parts	3074	found in table
	observ.	45.07		3040	merid. parts.

Correction in latit. 24 mer. diff. lat. 34. Then,

As 24 min. ·· min. 9.9 :: 35 min. ·· 14 min. the correction in longitude west; which being placed in the last column; and added (for that by the second case of the 13th rule preceding the Journal, in page 249. the ship hath out-run the reckoning) to 15 deg. 19 min. the longitude over it, the sum 15d. 33m. write underneath, which is corrected longitude the ship is in.

Lastly,

Lastly, To find the course and distance agreeable to the correction by observation; you have the corrected difference of latitude and departure; which according to chapter 3. section 3. problem 6. of plain-sailing, in page 60. is thus:

As the corrected difference of latitude, is to the corrected departure; so is radius, to the tangent of the course corrected. That is;

As m. 149.7 ·· m. 193.3 :: T. 45d. · T. 42d. 59m. south westerly, or SW by S $\frac{1}{4}$ W. And then,

As the S. course ·· departure :: radius ·· distance.

As S. 42d. 59.m. ·· m. 139.3 :: S. 90d. ·· 204m. corrected dist.

So that the course, and distance corrected by observation is SW by S. $\frac{3}{4}$ W. 204 minutes, which write in the journal for said day in page 257. Then the whole is finished, and the reckoning set to rights for that time.

And now, having largely showed the manner of these three days failing, how they are wrought, and placed in their proper columns in the journal, with an example of a correction by celestial observation; I leave the rest to the diligent learner's practice, for thy are done after the same manner: and the 23d of January you'll meet with another correction for your trial, which you may perform, if you studiously compare this one example with the preceding rules and directions, and with frequent practice, will sufficiently enlighten the way, the manner how, and the means whereby, to keep a Sea Reckoning or Journal (in this easy and commodious new method) with greater certainty than hath hitherto been taught.

And to invite all to keep their Sea Journals after this new method, which I dare presume will nearly quadrate with the forms practised by the ingenious; I have caused Paper Books to be ruled and intituled (in all respects) like to the Journal before going. Which you may be furnished with at reasonable rates, by B. Grierson at the King's-Arms in Parliament-Street.

Here follows several Tables useful in Navigation, with their Descriptions and Uses briefly and fully explained.

I. A Table of the difference of latitude and departure from the meridian.

II. A table of meridional parts, for the making Mercator's chart, and working questions in that kind of sailing.

III. A table of proportional parts, for supplying every minute of latitude in the table of meridional parts.

IV. A table of logarithms from 1 to 10,000.

V. A

V. A table of artificial sines, tangents, and seconds to every degree and minute of the quadrant, the radius being 10.000000.

VI. A table of angles which every rumb (or point of the compass) maketh with the meridian.

All of them carefully corrected, and exactly printed.

CHAP. I.

The explanation and use of the table of difference of latitude and departure from the meridian, in pages 273 274 and 275.

THIS table tho' standing in so little room as two pages, will give the difference of latitude and departure for any distance run, under 10.000; and for every quarter point of the compass.

The course stands at the head and foot of the table, at the head it begins at ¼ point, and then ½ point, ¾ points, increasing forwards to 4 points.

At the foot it begins at 4 points, and then 4 ¼ points, 4 ½ points 4 ¾ points, increasing backward to 7 ¾ points.

The distance run is placed in the two outermost columns of each page under and over the word Dist. both at the right-hand and at the left-hand, beginning at 1, and increasing downwards to 10, about half way each page; and then beginning again at 1, and from thence increasing to 10, at the foot of each page.

The difference of latitude and departure from the meridian, stands under the course at the head of the table, and over the course at the foot thereof; which are distinguished by the words Lat: and Dep.

The use of this table shall be made evident in resolving a single course (which is the first case of Plain Sailing) and traverse in these following Propositions

Proposition 10. *Course and distance run given; to find the difference of latitude and departure from the meridian.*

Example 1. *Admit a ship sails S by W ¼ W 6 minutes, I demand the difference of lat. and departure from the meridian.*

On the left-hand in page 284, (of the table under 1 ¼ point, and right against 6 minutes, under Dist. you'll find under

der the word lat.) 5.6492, and (under the word dep. 2.0213, for the difference of latitude, and departure required.

But it may ſuffice if the difference of latitude and departure be taken only in leagues or minutes, and tenth parts of a minute, or league; with this allowance, that is;

If the parts be		or more for it, ſet down		
	051		1	Tenth
	151		2	
	251		3	
	351		4	
	451		5	Tenths
	551		6	
	651		7	
	751		8	
	851		9	

And when the parts be 951, or more, then make the minutes or leagues of difference of Latitude and departure from the Meridian, 1. more than they are in the table. As for inſtance.

Inſtead of		ſet down		
	3.151		3.2	Tenths.
	6.151		6.2	
	7.259		7.3	
	8.960		9.	minutes or leagues.
	9.959		10.	

So then the aforeſaid Example S by W $\frac{1}{4}$ W. diſtance 6 min. being ſought in the table, find as before.

The			that is,		
	difference of lat.	5.6492		min.	5.6 tenths.
	departure —	2.0213		min.	2.0 tenths.

Example 2. *A ſhip ſails* SSW$\frac{1}{2}$W. 60 *minutes. I demand the difference of latitude and departure from the meridian.*

To perform this, count 1, at the beginning of the table, to be 10, and 2 to be 20; 3, 30; 4, 40; 5, 50; 6, 60; &c. to 10, which now ſtands for 100. According to this direction, againſt 6 (which now ſtands for 60) on the right-hand page 285. and under 2 $\frac{1}{2}$ points, ſtands 5.2915 under lat. and 28.284 under dep. which makes the difference of lat. 52.915 or min. 52.9 tenths, and the departure 28.284. or min. 28.3 tenths: for ob-

ſerve, that if the diſtance be 6 min. the difference of Latitude is 5.291. and departure 2.828. But,

$$\text{If the dist. be}\left\{\begin{array}{r}60\\600\\6000\end{array}\right\}\text{the diff. lat. is}\left\{\begin{array}{r}52.91\\529.1\\5291.\end{array}\right\}\text{and dep.}\left\{\begin{array}{r}28.28\\282.8\\2828.0\end{array}\right.$$

And after this manner you muſt increaſe the difference of Latitude and departure, as the diſtance doth increaſe.

Example 3. *Suppoſe a ſhip ſails* ESE $\frac{3}{4}$ E. 65m. *I demand the difference of latitude and departure, from the meridian?*

This muſt be looked out of the table at twice, that is, firſt find the difference of latitude and departure for diſtance 60 min. then find the difference of latitude and departure for diſtance 5 minutes, and add both together, which will ſhew you the difference of latitude and departure required: as here under you may ſee.

$$\text{For dist.}\left\{\begin{array}{r}\text{m.}\\60\\5\\\hline 65\end{array}\right\}\text{the diff. lat. is}\left\{\begin{array}{r}\text{m.}\\20.21\\1.68\\\hline 21.89\end{array}\right\}\text{and dep.}\left\{\begin{array}{r}\text{m.}\\56.49\\4.71\\\hline 61.20\end{array}\right.$$

That is, according to the former directions, the difference of latitude is m. 21.9 or minutes 21.9 tenths; and the departure 61.2 or minutes 61.2 tenths which was required.

Example 4. *A ſhip ſails* SW *by* S$\frac{1}{4}$W. 137 *minutes. I demand the difference of latitude and departure from the meridian.*

This muſt be taken out at thrice; that is, ſeek the difference of latitude and departure, for the diſtance m. 100, for m. 30 and for m. 7; add them together, as here under is done.

$$\text{For dist.}\left\{\begin{array}{r}\text{m.}\\100\\30\\7\\\hline 137\end{array}\right\}\text{diff. lat. is}\left\{\begin{array}{r}\text{m.}\\80.32\\24.10\\5.62\\\hline 110.04\end{array}\right\}\text{and dep.}\left\{\begin{array}{r}\text{m.}\\59.57\\17.87\\4.17\\\hline 81.61\end{array}\right.$$

That is, difference of latit. 110 min. and depart. m. 81.6 tenths.

Propoſition 11. *Several courſes and diſtances given; to find their differ. of lat. and departure, which, is the reſolving a traverſe.*

Example. *Admit a ſhip ſails* WSW. 106m. *then* W *by* N. m 10.4 *then* SW *by* W. 23m. *I demand the difference of latitude and departure with the direct courſe and diſtance from the firſt place.*

Theſe courſes and diſtances are taken from the foregoing journal, in page 252. being what the Log-Board made out for the firſt day after departing from the Lizard.

In order to the working this by the traverſe table, ſet down the ſeveral courſes and diſtances as in the table following.

Courſes

Courses	*Dist. inmin*	*Difference Latitude* N.	S.	*Departure.* E.	W.
W S W.	100.0 6.0		38.27 2.30		92.36 5.54
W by N.	100 0.4	1.95 0.08			9.81 0.39
S W by W	20.0 3.0		11.11 1.67		16.63 2.40
Summed up *Substracted*		2.03	53.35 2.03		127.25
		Lat.	51.32	*Dep.*	127.25

Then by Propoſition 1. find the difference of latitude and departure for each ſeveral courſe and diſtance; which place in their proper columns; that is, if the courſe be north eaſterly, place the difference of latitude in the north column under N, and the departure in the eaſt column under E. If the courſe be north weſterly, place the difference of latitude in the column under N, and the departure in the column under W.

If the courſe be ſouth eaſterly, place the diff. lat. in the ſouth column under S. and the departure in the eaſt column under E. but if the courſe be ſouth weſterly, place the difference of latitude in the ſouth column, and the departure in the weſt column

As for inſtance in the foregoing table; the firſt courſe is WSW the diſtance 106m. which is parted into two parts, *viz.* 100 and 6; and the courſe being ſouth weſterly, I place the difference of latit. m. 38.27 under S. and the dep. m. 92.36 under W. The like I do for the diſtance 6, as for the diſtance 100. The ſecond courſe is W by N. the diſtance 10.4 which is alſo looked out twice; and the difference of latitude 1.95. I place under N. and the departure 9.81 under W. the like you muſt do for the reſt.

Then having found the difference of lat. and departure for all the courſes, and inſerted their ſeveral differences of lat. and departures in their proper column: the next thing is to add up the N.S.E. and W. columns, and ſet their ſums underneath.

Then ſubtract the N and S columns the leſſer from the greater; and likewiſe the E and W columns.

As in the foregoing table the ſum of the N column is 2.03 of the S column 53.35 of the E column 0.00 and of the W column 127.25: and ſubtracting the N column from the S. the remainder is 51.32 the difference of latitude ſoutherly.

And ſubtracting the E column from the W the remainder is 127.25 the departure weſterly.

 Now

Now having the difference of latitude and departure you may find the courſe and diſtance by chapter 3. ſection 3. problem 6. of Plain Sailing, in page 60.

By which you will find the courſe to be near WSW the diſtance 138 minutes, as you may ſee in the Journal for the firſt day thereof, in page 252. and page 266.

CHAP. II.

The Uſe of the Table of Meridional Parts.

THIS table ſheweth the Meridional Parts for every minute of latitude; and is thus to be underſtood:

In the firſt column towards the left-hand (of each page) are the degrees of latit. from 1 to 89 degrees. In the next 6 columns are the Meridional Parts for every 5 minutes of latitude, anſwering to the degrees in the firſt column; and on the left-hand page are diſtinguiſhed, with 0m|5m|10m|15m|20m|25m| and on the right-hand page, with 30m|35m|40m|45m|50m|55m| at the head of the table.

In the laſt column of each page towards the right-hand are the differences in meridional Parts, to every 5 minutes of latitude; by the help of which, and the following table of Proportionable parts, the Meridional parts, to every minute of latitude may be found.

Prob. 12. *To find the meridional parts to every 5 minutes of latitude.*

Example 1. *Suppoſe the latitude of* 13d. 10m. *be given; to find the meridional parts belonging to it.*

Right againſt 13d. in the firſt column of page 286, and under 10m. (at the head of the table) in the 4th column, you will find the Meridional parts to be 797 minutes.

Exam. 2. *Admit you were to find the Meridional Parts anſwering to the latitude* 50d. 10m.

Right againſt 50d. in the 1ſt column in page 288, and under 10m. (at the head of the table) in the 4th column, you will find 3490, which are the Meridional Parts required.

CHAP.

CHAP. III.

The use of the table of Proportional Parts next following the Table of Meridional Parts.

THE use of this table, is to find the Meridional Parts to every minute of Latitude.

Proposition 13. *To find the Meridional Parts, for every minute of latitude.*

Example 1. *Suppose it were required to find the Meridional Parts for the latitude* 21d. 23m.

First, Find the Meridional Parts for the Latitude 21d. 20m. (20m. being the next even 5, which is less than 23m.) which you will find in page 286, to be 1311; and right against 21d. in the last column (noted with the difference at the head of the table) you will find 6.

Secondly, With this difference 6, go to the table of Proportional Parts, in page 292, and look 6 (in the first column thereof) under D, which stands for difference, and because 23m. is 3 more than 20, look under 3 at the head of the fourth column: so then right against 6 in the first column, and right under 3 you will find 3. which add to 1311, and it makes 1314 minutes the Meridional Parts for the latitude 21d. 23m. required.

Example 2. *Let it be required to find the Meridional Parts answering to the latitude* 51*d.* 49*m.*
The next less than 49m. is 45m. Therefore find the Meridional Parts for 41d. 45m. which is 3651, and right against 51d. in the column of difference is 8.

Now 49m. is 4m. above 45m. Therefore in the table of Proportional Parts right against 8, and under 4, you will find the Proportional Parts to be 6; which add to 3651, makes 3657 min. the Meridional Parts for the latitude 51d. 49m. required.

And thus much may suffice for the use of these tables, and for this discourse, which I hope is plain and easy to every reader.

A TABLE of Difference of Latitude and Departure from the Meridian.

Dist.	¼ Points. Lat.	¼ Points. Dep.	½ Point. Lat.	½ Point. Dep.	¾ Point. Lat.	¾ Point. Dep.	1 Point. Lat.	1 Point. Dep.	Dist.
1	0.9988	0.0191	0.9952	0.0980	0.9292	0.1467	0.9808	0.1951	1
2	1.6976	0.0981	1.9903	0.1960	1.9784	0.2935	1.9616	0.3902	2
3	2.9964	0. 472	2.9855	0.2941	2.9675	0.4402	2.9424	0.585[illegible]	3
4	3.9952	0.1963	3.9807	0.3921	3.9567	0.5861	3.9232	0.7804	4
5	4.9940	0.2454	4.9759	0.4901	4.9459	0.7337	4.9040	0.9555	5
6	5.9927	0.2944	5.9711	0.5881	5.9351	0.8804	5.8847	1.1705	6
7	6.9915	0.3435	6.9663	0.6861	6.9243	1.0271	6.8655	1.3656	7
8	7.9903	0.3926	7.9615	0.7842	7.9134	1.1738	7.8463	1.0607	8
9	8.9891	0.4416	8.9567	0.8822	8.9026	1.3206	8.8271	1.7558	9
10	9.9879	0.4907	9.9519	0.9802	9.8918	1.4673	9.8079	1.9509	10
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	7¾ Points.		7 ½ Points		7 ¼ Points.		7 Points.		

Dist.	1 ¼ Point. Lat.	1 ¼ Point. Dep.	1 ½ Point. Lat.	1 ½ Point. Dep.	1 ¾ Point. Lat.	1 ¾ Point. Dep.	2 Points. Lat.	2 Points. Dep.	Dist.
1	0.9700	0.2430	0.9569	0.2903	0.9415	0.3369	0.9239	0.3827	1
2	1.9400	0.4860	1.9138	0.5806	1.8831	0.6738	1.8478	0.7654	2
3	2.9101	0.7289	2.8708	0.8703	2.8205	1.0107	2.7716	1.1480	3
4	3.8801	0.9719	3.8278	1.1612	3.7662	1.3476	3.4955	1.5307	4
5	4.8501	1.2149	4.7847	1.4515	4.7077	1.6845	4.6194	1.9133	5
6	5.8201	1.4579	5.7416	1.7417	5.6492	2.0213	5.5433	2.2961	6
7	6.7901	1.7009	6.6986	2.0320	6.5908	2.3582	6.4672	2.6788	7
8	7.7602	1.9438	7.8555	2.3223	7.5323	2.6851	7.3910	3.0614	8
9	8.7302	2.1868	8.6125	2.0146	8.4739	3.0320	8.3149	3.4441	9
10	9.7002	2.4298	9.5694	2.0029	9.4154	3.3689	9.2388	3.8268	10
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	6 ¾ Points.		6 ½ Points.		6 ¼ Points		6 Points.		

A TABLE *of difference of latitude and departure from the meridian.*

Dist.	2 ¼ Points.		2 ½ Points.		2 ¾ Points.		3 Points.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.9040	0.4276	0.8819	0.4714	0.8577	0.5149	0.8315	0.5556	1
2	1.8080	0.8551	1.7638	0.9428	1.7155	1.0282	1.6629	1.1111	2
3	2.7120	1.2827	2.6458	1.4142	2.5732	1.5423	2.4944	1.6667	3
4	3.6160	1.7102	3.5277	1.8856	3.4302	2.0564	3.3259	2.2223	4
5	4.5200	2.1378	4.4926	2.3570	4.2887	2.5705	4.1574	2.7779	5
6	5.4240	2.5654	5.2915	2.8284	5.1464	3.0846	4.9888	3.3334	6
7	6.3280	2.9929	6.1734	3.2998	6.0041	3.5987	5.8208	3.8890	7
8	7.2320	3.4205	7.0554	3.7712	6.8618	4.1128	6.6518	4.4446	8
9	8.1360	3.8480	7.9393	4.2446	7.7196	4.6269	7.4832	5.0001	9
10	9.0400	4.2756	8.8172	4.7140	8.5773	5.1410	8.3147	5.5557	10
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	5 ¾ Points.		5 ½ Points.		5 ¼ Points.		5 Points.		

Dist.	3 ¼ Points.		3 ½ Points.		3 ¾ Points.		4 Points.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.8032	0.5957	0.7730	0.6344	0.7410	0.6716	0.7071	0.7071	1
2	1.6064	1.1914	1.5460	1.2688	1.4819	1.3431	1.4142	1.4142	2
3	2.4096	1.7871	2.3190	1.9032	2.2229	2.0147	2.1213	2.1213	3
4	3.2128	2.3828	3.0920	2.5376	2.9638	2.6862	2.8284	2.8284	4
5	4.0161	2.7385	3.8651	3.1720	3.7048	3.3578	3.5356	3.5356	5
6	4.8193	3.5742	4.6381	3.8064	4.4457	4.0294	4.2427	4.2427	6
7	5.6225	4.1699	5.4111	4.4408	5.1867	4.7009	4.9498	4.9498	7
8	6.4257	4.7656	6.1841	5.0752	5.9276	5.3725	5.6569	5.6569	8
9	7.2289	5.3613	6.9571	5.7096	6.6686	6.0448	6.3640	6.3640	9
10	8.0321	5.9570	7.7301	6.3440	7.4095	6.7156	7.0711	7.0711	10
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	4 ¾ Points.		4 ½ Points.		4 ¼ Points.		4 Points.		

The deg. of lat.	The minutes of each degree.						The difference.
	om	5m	10m	15m	23m	25m	
	The meridional parts						
0	0	5	10	15	20	25	5
1	60	65	70	75	80	85	5
2	120	125	130	135	140	145	5
3	180	185	190	195	200	205	5
4	2[illegible]	245	250	255	260	265	5
5	300	350	310	315	320	325	5
6	361	366	371	376	381	386	5
7	421	426	431	436	441	446	5
8	482	487	492	497	502	507	5
9	542	547	552	557	562	567	5
10	603	608	613	618	623	628	5
11	664	669	674	679	684	690	5
12	725	730	736	741	746	751	5
13	787	792	797	892	8 7	812	5
14	848	854	859	864	869	874	5
15	910	916	921	926	931	936	5
16	973	978	983	988	994	999	5
17	1035	1041	1046	1051	1056	1061	5
18	1098	1103	1109	1114	1119	1125	5
19	1161	1167	1172	1177	1183	1188	5
20	1225	1230	1236	1241	1246	1252	5
21	1289	1295	1300	1305	1311	1316	5
22	1354	1359	1364	1370	1375	1381	6
23	1419	1424	1429	1435	1440	1446	6
24	1484	1490	1495	1500	1506	1511	6
25	1550	1556	1561	1567	1572	1578	6
26	1616	1622	1628	1633	1639	1644	6
27	1684	1689	1695	1700	1706	1712	6
28	1751	1757	1762	1768	1774	1780	6
29	1819	1825	1831	1837	1842	1848	6

The deg. of lat.	30m.	35m.	40m.	45m.	50m.	55m.	The difference
	The meridional parts.						
0	30	35	40	45	50	55	5
1	90	95	100	105	110	115	5
2	150	155	160	165	170	175	5
3	210	215	220	225	230	235	5
4	270	375	280	285	290	295	5
5	330	335	341	346	351	356	5
6	391	396	401	406	411	416	5
7	451	456	461	466	471	476	5
8	512	517	522	527	532	537	5
9	573	578	583	588	593	598	5
10	634	639	644	649	654	659	5
11	695	700	705	710	715	720	5
12	756	761	766	771	776	781	5
13	818	823	828	833	838	843	5
14	879	885	890	895	900	905	5
15	942	947	952	957	962	967	5
16	1004	1009	1014	1020	1025	1030	5
17	1067	1072	1077	1082	1088	1093	5
18	1130	1135	1140	1146	1151	1156	5
19	1193	1199	1204	1209	1214	1220	5
20	1257	1262	1268	1273	1278	1284	5
21	1321	1327	1332	1338	1343	1348	5
22	1386	1392	1397	1402	1408	1413	6
23	1451	1457	1462	1468	1473	1479	6
24	1517	1522	1528	1535	1539	1544	6
25	1583	1589	1594	1600	1605	1611	6
26	1650	1656	1661	1667	1672	1678	6
27	1717	1723	1729	1734	1740	1746	6
28	1785	1791	1797	1802	1808	1814	6
29	1854	1860	1865	1871	1877	1883	6

The deg. of lat.	The minutes of each degree.						The difference.
	0m.	5m.	10m.	15m.	20m.	25m.	
	The meridional parts.						
30	1888	1894	1900	1906	1912	1917	6
31	1958	1964	1970	1976	1981	1987	6
32	2028	2034	2040	2046	2052	2058	6
33	2100	2105	2111	2117	2123	2129	6
34	2171	2177	2184	2190	2196	2202	6
35	2244	2250	2257	2263	2269	2272	6
36	2318	2324	2330	2337	2343	2349	6
37	2393	2399	2405	2411	3418	2424	6
38	2468	2475	2481	2487	2494	2500	6
39	2545	2551	2558	2564	2571	2577	6
40	2623	2629	2636	2642	2649	2655	6
41	2702	2708	2715	2722	2728	2735	7
42	2782	2788	2795	2802	2809	2815	7
43	2893	2870	2877	2884	2891	2807	7
44	2946	2953	2960	2967	2974	2981	7
45	3030	3037	3044	3051	3058	3065	7
46	3116	3123	3130	3137	3144	3152	7
47	3203	3210	3217	3225	3232	3240	8
48	3292	3299	3006	3314	3322	3329	8
49	3382	3390	3397	3405	3413	3420	8
50	3474	3482	3490	3498	3506	3514	8
51	3569	3577	3585	3593	3601	3609	8
52	3665	3673	3621	3690	3698	3706	8
53	3764	3772	3780	3789	3796	3806	8
54	3835	3837	3882	3890	3899	3907	8
55	3968	3977	3985	3994	4003	4012	9
56	4047	4083	4092	4101	4110	4119	9
57	4183	4192	4201	4210	4220	4229	9
58	4294	4304	4313	4323	4332	4342	10
59	4409	4419	4429	4438	4448	2458	19

The deg. of lat.	The minutes of each degree.						The difference.
	30m.	35m.	40m.	45m.	50m.	55m.	
	The meridional parts.						
30	1923	1929	1935	1941	1946	1952	6
31	1993	1999	2005	2011	2017	2022	6
32	2064	2070	2076	2082	2088	2094	6
33	2135	2141	2147	2153	2159	2165	6
34	2208	2214	2220	2226	2232	2238	6
35	2281	2287	2293	2299	2306	2312	6
36	2355	2363	2368	2374	2380	2386	6
37	2430	2437	2443	2449	2456	2462	6
38	2506	2513	2519	2526	2532	2538	6
39	2584	2590	2597	2603	2610	2616	6
40	2662	2669	2675	2682	2688	2695	6
41	2742	2748	2755	2762	2768	2775	7
42	2822	2829	2836	2843	2849	2856	7
43	2904	2911	2918	2925	2932	2939	7
44	2988	2995	3002	3009	3016	3023	7
45	3073	3080	3087	3094	3101	3108	7
46	3159	3166	3173	3181	3188	3195	7
47	3247	3254	3262	3269	3277	3284	8
48	3337	3344	3352	3359	3367	3374	8
49	3428	3436	3443	3451	3459	3467	8
50	3521	3529	3537	3545	3553	3560	8
51	3617	3625	3633	3641	3649	3657	8
52	3714	3722	3731	3739	3747	3755	8
53	3814	3822	3831	3839	3848	3856	8
54	3916	3925	3933	3942	3951	3959	8
55	4021	4029	4038	4047	4056	4065	9
56	4128	4137	4146	4155	4164	4173	9
57	4238	4247	4257	4266	4275	4285	9
58	4351	4361	4370	4380	4390	4299	10
59	4468	4478	4488	4497	4507	4517	10

The deg. of lat.	*The minutes of each degree.*						*The difference*
	0m.	5m.	10m.	15m.	20m.	25m.	
	The meridional parts.						
60	4527	4537	4547	4557	4508	4578	10
61	4649	4660	4670	4680	4691	4701	10
62	4775	4786	4796	4807	4818	4829	11
63	4905	4916	4927	4938	4949	4960	11
64	5039	5051	5062	5704	5085	5097	12
65	5179	5191	5203	5214	5226	5238	12
66	5324	5336	5348	5361	5373	5385	12
67	5474	5487	5500	5513	5526	5539	13
68	5631	5644	5658	5671	5685	5698	13
69	5795	5809	5823	5837	5851	5865	14
70	5966	5981	5995	6010	6025	6040	15
71	6146	6161	6177	6192	6208	6223	15
72	6335	6351	6367	6384	6400	6417	16
73	6534	6552	6569	6586	6603	6621	17
74	6746	6764	6782	6801	6819	6838	18
75	6970	6990	7009	7029	7048	7068	20
76	7210	7231	7252	7273	7294	7315	21
77	7467	7490	7512	7535	7557	7580	23
78	7745	7769	7793	7817	7842	7867	25
79	8046	8072	8099	8125	8152	8179	27
80	8375	8404	8433	8463	8492	8522	30
81	8739	8771	8803	8836	8869	8903	33
82	9145	9182	9218	9255	9292	9330	37
83	9906	9647	9689	9731	9774	9817	43
84	10137	10185	10234	10283	10334	10385	51
85	10765	10822	10881	10941	11002	11064	62
86	11533	11605	11679	11755	11832	11911	77
87	12521	12619	12170	12821	12927	13036	109
88	13916	14063	14216	14376	14543	14720	
89	16300	16599	16926	17289	17693	18153	

The deg. of lat.	*The minutes of each degree.*						*The difference.*
	30m.	35m.	40m.	45m.	50m.	55m.	
	The meridional parts.						
60	4588	4598	4608	4618	4629	4639	10
61	4712	4722	4733	4743	4754	4764	10
62	4839	4850	4861	4872	4883	4894	11
63	4972	4983	4994	5005	5017	5028	11
64	5108	5120	5132	5143	5155	5167	12
65	5250	5263	5275	5287	5299	5311	12
66	5398	5411	5423	5436	5449	5461	12
67	5552	5565	5578	5592	5604	5617	13
68	5712	5725	5739	5753	5767	5781	14
69	5879	5894	5908	5922	5937	5951	14
70	6055	6070	6085	6100	6115	6130	15
71	6239	6255	6271	6287	6303	6319	16
72	6433	6450	6467	6483	6500	6517	17
73	6639	6656	6674	6692	6710	6728	18
74	6856	6875	6894	6913	6932	6954	19
75	7088	7108	7128	7149	7169	7189	20
76	7336	7358	7379	7401	7423	7445	22
77	7603	7626	7650	7673	7697	7722	24
78	7892	7917	7942	7968	7994	8020	26
79	8207	8234	8232	8290	8318	8347	28
80	8552	8583	8614	8644	8976	8707	31
81	8936	8970	9005	9039	9074	9110	36
82	9368	9407	9445	9485	9525	9565	40
83	9861	9906	9951	9996	10043	10098	46
84	10437	10489	10542	10597	10652	10707	55
85	11127	11192	11257	11324	11392	11462	68
86	11992	12075	12160	12247	12336	12428	89
87	13149	13266	13386	13511	13641	13776	
88	14906	15102	15311	15532	15770	16024	
89	18683	19309	20067	21065	22459	24842	

D	1	2	3	4
5	1	2	3	4
6	1	2	3	5
7	1	3	4	6
8	2	3	5	6
9	2	4	5	7
10	2	4	6	8
11	2	4	7	9
12	2	5	7	10
13	3	5	8	10
14	3	6	8	11
15	3	6	9	12
16	3	6	10	13
17	3	7	10	14
18	4	7	11	14
19	4	8	11	15
20	4	8	12	16
21	4	8	13	17
22	4	9	13	18
23	5	6	14	18
24	5	10	14	19

D	1	2	3	4
25	5	10	15	20
26	5	10	16	21
27	5	11	16	22
28	6	11	17	22
30	6	12	18	24
31	6	12	19	25
33	7	13	20	26
35	7	14	21	28
37	7	15	22	30
40	8	16	24	32
42	8	17	25	34
46	9	18	28	37
50	10	20	30	40
55	11	22	33	44
61	12	24	37	49
68	14	27	41	54
76	15	30	46	61
88	18	35	53	70
105	21	63	53	84
115	22	69	69	92

A Table

A

TABLE

OF

LOGARITHMS.

For NUMBERS increasing in their Natural Order, from Unity to 10,000.

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
1	0.00000	46	1.66276	91	1.95904	136	2.13354
2	0.30103	47	1.67210	92	1.96379	37	2.13672
3	0.47712	48	1.68124	93	1.96848	38	2.13988
4	0.60206	49	1.69020	94	1.97313	39	2.14301
5	0.69897	50	1.69897	95	1.97772	40	2.14613
6	0.77815	51	1.70757	96	1.98227	41	2.14922
7	0.84510	52	1.71600	97	1.98677	42	2.15229
8	0.90309	53	1.72428	98	1.99123	43	2.15534
9	0.95424	54	1.73239	99	1.99564	44	2.15836
10	1.00000	55	1.74036	100	2.00000	45	2.16137
11	1.04139	56	1.74819	101	2.00432	46	2.16435
12	1.07918	57	1.75587	02	2.00860	47	2.16732
13	1.11394	58	1.76342	03	2.01284	48	2.17026
14	1.14613	59	1.77085	04	2.01703	49	2.17319
15	1.17609	60	1.77815	05	2.02119	50	2.17609
16	1.20412	61	1.78533	06	2.02531	51	2.17898
17	1.23045	62	1.79239	07	2.02938	52	2.18184
18	1.25527	63	1.79934	08	2.03342	53	2.18469
19	1.27875	64	1.80618	09	2.03743	54	2.18752
20	1.30103	65	1.81291	10	2.04139	55	2.19033
21	1.32222	66	1.81954	11	2.04532	56	2.19312
22	1.34242	67	1.82607	12	2.04922	57	2.19590
23	1.36173	68	1.83251	13	2.05308	58	2.19866
24	1.38021	69	1.83885	14	2.05690	59	2.20140
25	1.39794	70	1.84510	15	2.06070	60	2.20412
26	1.41497	71	1.85126	16	2.06446	61	2.20683
27	1.43136	72	1.85733	17	2.06819	62	2.20952
28	1.44716	73	1.86332	18	2.07188	63	2.21219
29	1.46240	74	1.86923	19	2.07555	64	2.21484
30	1.47712	75	1.87506	20	2.07918	65	2.21748
31	1.49136	76	1.88081	21	2.08279	66	2.22011
32	1.50515	77	1.88649	22	2.08636	67	2.22272
33	1.51851	78	1.89209	23	2.08991	68	2.22531
34	1.53148	79	1.89762	24	2.09342	69	2.22789
35	1.54407	80	1.90309	25	2.09691	70	2.23045
36	1.55630	81	1.90849	26	2.10037	71	2.23300
37	1.56820	82	1.91381	27	2.10380	72	2.23553
38	1.57978	83	1.91908	28	2.10721	73	2.23805
39	1.59106	84	1.92428	29	2.11059	74	2.24055
40	1.60206	85	1.92942	30	2.11394	75	2.24304
41	1.61278	86	1.93450	31	2.11727	76	2.24551
42	1.62325	87	1.93952	32	2.12057	77	2.24797
43	1.63347	88	1.94448	33	2.12385	78	2.25042
44	1.64345	89	1.94939	34	2.12710	79	2.25285
[illegible]	[illegible]	[illegible]	[illegible]	35	2.13033	80	2.25527

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
181	2.25768	226	2.35411	271	2.43297	316	2.49969
82	2.26007	27	2.35603	72	2.43457	17	2.50106
83	2.26245	28	2.35793	73	2.43616	18	2.50243
84	2.26482	29	2.35984	74	2.43775	19	2.50379
85	2.26717	30	2.36173	75	2.43933	20	2.50515
86	2.26951	31	2.36361	76	2.44091	21	2.50651
87	2.27184	32	2.36549	77	2.44248	22	2.50786
88	2.27416	33	2.36736	78	2.44404	23	2.50920
89	2.27646	34	2.36922	79	2.44560	24	2.51055
90	2.27875	35	2.37107	80	2.44716	25	2.51188
91	2.28103	36	2.37291	81	2.44871	26	2.51322
92	2.28330	37	2.37475	82	2.45025	27	2.51455
93	2.28556	38	2.37658	83	2.45179	28	2.51587
94	2.28780	39	2.37840	84	2.45332	29	2.51720
95	2.29003	40	2.38021	85	2.45484	30	2.51851
96	2.29226	41	2.38202	86	2.45637	31	2.51983
97	2.29447	42	2.38382	87	2.45788	32	2.52114
98	2.29667	43	2.38561	88	2.45939	33	2.52244
99	2.29885	44	2.38739	89	2.46090	34	2.52375
200	2.30103	45	2.38917	90	2.46240	35	2.52504
201	2.30320	46	2.39094	91	2.46389	36	2.52634
02	2.30535	47	2.39270	92	2.46538	37	2.52763
03	2.30750	48	2.39445	93	2.46687	38	2.52892
04	2.30963	49	2.39620	94	2.46835	39	2.53020
05	2.31175	50	2.39794	95	2.46982	40	2.53148
06	2.31387	51	2.39967	96	2.47129	41	2.53275
07	2.31597	52	2.40140	97	2.47276	42	2.53403
08	2.31806	53	2.40312	98	2.47422	43	2.53529
09	2.32015	54	2.40483	99	2.47567	44	2.53656
10	2.32222	55	2.40654	300	2.47712	45	2.53782
11	2.32428	56	2.40824	301	2.47857	46	2.53908
12	2.32634	57	2.40993	02	2.48001	47	2.54033
13	2.32838	58	2.41162	03	2.48144	48	2.54158
14	2.33041	59	2.41330	04	2.48287	49	2.54283
15	2.33244	60	2.41497	05	2.48430	50	2.54407
16	2.33445	61	2.41664	06	2.48572	51	2.54531
17	2.33646	62	2.41830	07	2.48714	52	2.54654
18	2.33846	63	2.41996	08	2.48855	53	2.54777
19	2.34044	64	2.42160	09	2.48996	54	2.54900
20	2.34242	65	2.42325	10	2.49136	55	2.55023
21	2.34439	66	2.42488	11	2.49276	56	2.55145
22	2.34635	67	2.48651	12	2.49415	57	2.55267
23	2.34830	68	2.42813	13	2.49554	58	2.55388
24	2.35025	69	2.42975	14	2.49693	59	2.55509
25	2.35218	70	2.43136	15	2.49831	60	2.55630

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
361	2.55751	406	2.60853	451	2.65418	496	2.69548
62	2.55871	07	2.60959	52	2.65514	97	2.69636
63	2.55991	08	2.61066	53	2.65610	98	2.69723
64	2.56110	09	2.61172	54	2.65706	99	2.69810
65	2.56229	10	2.61278	55	2.65801	500	2.69897
66	2.56348	11	2.61384	56	2.65896	01	2.69984
67	2.56467	12	2.61490	57	2.65992	02	2.70070
68	2.56585	13	2.61595	58	2.66087	03	2.70157
69	2.56703	14	2.61700	59	2.66181	04	2.70243
70	2.56820	15	2.61805	60	2.66276	05	2.70329
71	2.56937	16	2.61909	61	2.66370	06	2.70415
72	2.57054	17	2.62014	62	2.66464	07	2.70501
73	2.57171	18	2.62118	63	2.66558	08	2.70586
74	2.57287	19	2.62221	64	2.66652	09	2.70672
75	2.57403	20	2.62325	65	2.66745	10	2.70757
76	2.57519	21	2.62428	66	2.66839	11	2.70842
77	2.57634	22	2.62531	67	2.66932	12	2.70927
78	2.57749	23	2.62634	68	2.67025	13	2.71012
79	2.57864	24	2.62737	69	2.67117	14	2.71099
80	2.57978	25	2.62839	70	2.67210	15	2.71181
81	2.58093	26	2.62941	71	2.67302	16	2.71265
82	2.58206	27	2.63043	72	2.67394	17	2.71349
83	2.58320	28	2.63144	73	2.67486	18	2.71433
84	2.58433	29	2.63246	74	2.67578	19	2.71517
85	2.58546	30	2.63347	75	2.67669	20	2.71600
86	2.58659	31	2.63448	76	2.67761	21	2.71684
87	2.58771	32	2.63548	77	2.67852	22	2.71767
88	2.58883	33	2.63649	78	2.67943	23	2.71850
89	2.58995	34	2.63749	79	2.68034	24	2.71933
90	2.59106	35	2.63849	80	2.68124	25	2.72016
91	2.59218	36	2.63949	81	2.68215	26	2.72099
92	2.59329	37	2.64048	82	2.68305	27	2.72181
93	2.59439	38	2.64147	83	2.68395	28	2.72263
94	2.59550	39	2.64246	84	2.68485	29	2.72346
95	2.59660	40	2.64345	85	2.68574	30	2.72428
96	2.59770	41	2.64444	86	2.68664	31	2.72509
97	2.59879	42	2.64542	87	2.68753	32	2.72591
98	2.59988	43	2.64640	88	2.68842	33	2.72673
99	2.60097	44	2.64738	89	2.68931	34	2.72754
400	2.60206	45	2.64836	90	2.69020	35	2.72835
401	2.60314	46	2.64933	91	2.69108	36	2.72916
02	2.60423	47	2.65031	92	2.69197	37	2.72997
03	2.60531	48	2.65128	93	2.69285	38	2.73078
04	2.60638	49	2.65225	94	2.69373	39	2.73159
05	2.60746	50	2.65321	95	2.69461	40	2.73239

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
541	2.73320	586	2.76790	631	2.80003	676	2.82995
42	2.73400	87	2.76864	32	2.80072	77	2.83059
43	2.73480	88	2.76938	33	2.80140	78	2.83123
44	2.73560	89	2.77012	34	2.80209	79	2.83187
45	2.73640	90	2.77085	35	2.80277	80	2.83251
46	2.73719	91	2.77159	36	2.80346	81	2.83315
47	2.73799	92	2.77232	37	2.80414	82	2.83378
48	2.73878	93	2.77305	38	2.80482	83	2.83442
49	2.73957	94	2.77379	39	2.80550	84	2.83506
50	2.74036	95	2.77452	40	2.80618	85	2.83569
51	2.74115	96	2.77525	41	2.80686	86	2.83632
52	2.74194	97	2.77597	42	2.80754	87	2.83696
53	2.74273	98	2.77670	43	2.80821	88	2.83759
54	2.74351	99	2.77743	44	2.80889	89	2.83822
55	2.74429	600	2.77815	45	2.80956	90	2.83885
56	2.74507	601	2.77887	46	2.81023	91	2.83948
57	2.74586	02	2.77960	47	2.81090	92	2.84011
58	2.74663	03	2.78032	48	2.81158	93	2.84073
59	2.74741	04	2.78104	49	2.81224	94	2.84136
60	2.74819	05	2.78176	50	2.81291	95	2.84198
61	2.74896	06	2.78247	51	2.81358	96	2.84261
62	2.74974	07	2.78319	52	2.81425	97	2.84323
63	2.75051	08	2.78390	53	2.81491	98	2.84386
64	2.75128	09	2.78462	54	2.81558	99	2.84448
65	2.75205	10	2.78533	55	2.81624	700	2.84510
66	2.75282	11	2.78604	56	2.81690	701	2.84572
67	2.75358	12	2.78675	57	2.81757	02	2.84634
68	2.75435	13	2.78746	48	2.81823	03	2.84696
69	2.75511	14	2.78817	59	2.81889	04	2.84757
70	2.75587	15	2.78888	60	2.81954	05	2.84819
71	2.75664	16	2.78958	61	2.82020	06	2.84880
72	2.75740	17	2.79029	62	2.82086	07	2.84942
73	2.75815	18	2.79099	63	2.82151	08	2.85003
74	2.75891	19	2.79169	64	2.82217	09	2.85065
75	2.75967	20	2.79239	65	2.82282	10	2.85126
76	2.76042	21	2.79309	66	2.82347	11	2.85187
77	2.76118	22	2.79379	57	2.82413	12	2.85248
78	2.76193	23	2.79449	68	2.82478	13	2.85309
79	2.76268	24	2.79518	69	2.82543	14	2.85370
80	2.76343	25	2.79588	70	2.82607	15	2.85431
81	2.76418	26	2.79657	71	2.82672	16	2.85491
82	2.76492	27	2.79727	72	2.82737	17	2.85552
83	2.76567	28	2.79796	73	2.82802	18	2.85612
84	2.76641	29	2.79865	74	2.82866	19	2.85673
85	2.76716	30	2.79934	75	2.82930	20	2.85733

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
721	2.85794	766	2.88423	811	2.90902	856	2.93247
22	2.85854	67	2.88480	12	2.90956	57	2.93298
23	2.85914	68	2.88536	13	2.91009	58	2.93349
24	2.85974	69	2.88593	14	2.91062	59	2.93399
25	2.86034	70	2.88649	15	2.91116	60	2.93450
26	2.86094	71	2.88705	16	2.91169	61	2.93500
27	2.86153	72	2.88762	17	2.91222	62	2.93551
28	2.86213	73	2.88818	18	2.91275	63	2.93601
29	2.86273	74	2.88874	19	2.91328	64	2.93651
30	2.86332	75	2.88930	20	2.91381	65	2.93702
31	2.86392	76	2.88986	21	2.91434	66	2.93752
32	2.86451	77	2.89042	22	2.91487	67	2.93802
33	2.86510	78	2.89098	23	2.91540	68	2.93852
34	2.86570	79	2.89154	24	2.91593	69	2.93902
35	2.86629	80	2.89209	25	2.91645	70	2.93952
36	2.86688	81	2.89265	26	2.91698	71	2.94002
37	2.86747	82	2.89321	27	2.91751	72	2.94052
38	2.86806	83	2.89376	28	2.91803	73	2.94101
39	2.86864	84	2.89432	29	2.91855	74	2.94151
40	2.86923	85	2.89487	30	2.91908	75	2.94201
41	2.86982	86	2.89542	31	2.91960	76	2.94250
42	2.87040	87	2.89597	32	2.92012	77	2.94300
43	2.87099	88	2.89653	33	2.92065	78	2.94349
44	2.87157	89	2.89708	34	2.92117	79	2.94399
45	2.87216	90	2.89763	35	2.92169	80	2.94448
46	2.87274	91	2.89818	36	2.92221	81	2.94498
47	2.87332	92	2.89872	37	2.92273	82	2.94547
48	2.87390	93	2.89927	38	2.92324	83	2.94596
49	2.87448	94	2.89982	39	2.92376	84	2.94645
50	2.87506	95	2.90037	40	2.92428	85	2.94694
51	2.87564	96	2.90091	41	2.92480	86	2.94743
52	2.87622	97	2.90146	42	2.92531	87	2.94792
53	2.87680	98	2.90200	43	2.92583	88	2.94841
54	2.87737	99	2.90255	44	2.92634	89	2.94890
55	2.87795	800	2.90309	45	2.92686	90	2.94939
56	2.87852	801	2.90363	46	2.92737	91	2.94988
47	2.87910	02	2.90417	47	2.92788	92	2.95036
58	2.87967	03	2.90472	48	2.92840	93	2.95085
59	2.88024	04	2.90526	49	2.92891	94	2.95135
60	2.88081	05	2.90580	50	2.92942	95	2.95182
61	2.88138	06	2.90634	51	2.92993	96	2.95231
62	2.88196	07	2.90687	52	2.93044	97	2.95279
63	2.88252	08	2.90741	53	2.93095	98	2.95328
64	2.88309	09	2.90795	54	2.93146	09	2.95376
65	2.88366	10	2.90849	55	2.93197	900	2.95424

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
901	2.95472	946	2.97589	991	2.99607	1036	3.01536
02	2.95521	47	2.97635	992	2.99651	37	3.01578
03	2.95569	48	2.97681	993	2.99695	38	3.01620
04	2.95617	49	2.97727	994	2.99739	39	3.01662
05	2.95665	50	2.97772	995	2.99782	40	3.01703
06	2.95713	51	2.97818	996	2.99826	41	3.01745
07	2.95761	52	2.97864	997	2.99870	42	3.01787
08	2.95809	53	2.97909	998	2.99913	43	3.01828
09	2.95856	54	2.97955	999	2.99957	44	3.01870
10	2.95904	55	2.98000	1000	3.00000	45	3.01912
11	2.95952	56	2.98046	1001	3.00043	46	3.01953
12	2.95999	57	2.98091	02	3.00087	47	3.01995
13	2.96047	58	2.98137	03	3.00130	48	3.02036
14	2.96095	59	2.98182	04	3.00173	49	3.02078
15	2.96142	60	2.98227	05	3.00217	50	3.02119
16	2.96190	61	2.98272	06	3.00260	51	3.02160
17	2.96237	62	2.98318	07	3.00303	52	3.02202
18	2.96284	63	2.98363	08	3.00346	53	3.02243
19	2.96332	64	2.98408	09	30.0389	54	3.02284
20	2.96379	65	2.98453	10	3.00432	55	3.02325
21	2.96426	66	2.98498	11	3.00475	56	3.02366
22	2.96473	67	2.98543	12	3.00518	57	3.02408
23	2.96520	68	2.98588	13	3.00561	58	3.02449
24	2.96567	69	2.98632	14	3.00604	59	3.02490
25	2.96614	70	2.98677	15	3.00647	60	3.02531
26	2.96661	71	2.98722	16	3.00689	61	3.02572
27	2.96708	72	2.98767	17	3.00732	62	3.02613
28	2.96755	73	2.98811	18	3.00774	63	3.02653
29	2.96802	74	2.98856	19	3.00817	64	3.02694
30	2.96848	75	2.98900	20	3.00860	65	3.02735
31	2.96895	76	2.98945	21	3.00903	66	3.02776
32	2.96942	77	2.98989	22	3.00945	67	3.02816
33	2.96988	78	2.99034	23	3.00988	68	3.02857
34	2.97035	79	2.99078	24	3.01030	69	3.02898
35	2.97081	80	2.99123	25	3.01072	70	3.02938
36	2.97128	81	2.99167	26	3.01115	71	3.02979
37	2.97174	82	2.99211	27	3.01157	72	3.03019
38	2.97220	83	2.99255	28	3.01199	73	3.03060
39	2.97267	84	2.99300	29	3.01242	74	3.03100
40	2.97312	85	2.99344	30	3.01284	75	3.03141
41	2.97359	86	2.99388	31	3.01326	76	3.03181
42	2.97405	87	2.99432	32	3.01368	77	3.03222
43	2.97451	88	2.99476	33	3.01410	78	3.03262
44	2.97497	89	2.99520	34	3.01452	79	3.03302
45	2.97543	90	2.99564	35	3.01494	80	3.03342

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
1081	3.03383	1126	3.05154	1171	3.06856	1216	3.08493
82	3.03423	27	3.05192	72	3.06893	17	3.08529
83	3.03463	28	3.05231	73	3.06930	18	3.08565
84	3.03503	29	3.05269	74	3.06967	19	3.08600
85	3.03543	30	3.05308	75	3.07004	20	3.08636
86	3.03583	31	3.05346	76	3.07041	21	3.08672
87	3.03623	32	3.05385	77	3.07078	22	3.08707
88	3.03663	33	3.05423	78	3.07115	23	3.08743
89	3.03703	34	3.05461	79	3.07151	24	3.08778
90	3.03743	35	3.05500	80	3.07188	25	3.08814
91	3.03782	36	3.05538	81	3.07225	26	3.08849
92	3.03822	37	3.05576	82	3.07262	27	3.08884
93	3.03862	38	3.05614	83	3.07298	28	3.08920
94	3.03902	39	3.05652	84	3.07335	29	3.08955
95	3.03941	40	3.05690	85	3.07372	30	3.08991
96	3.03981	41	3.05729	86	3.07408	31	3.09026
97	3.04021	42	3.05767	87	3.07445	32	3.09061
98	3.04060	43	3.05805	88	3.07482	33	3.09096
99	3.04100	44	3.05843	89	3.07518	34	3.09132
1100	3.04139	45	3.05881	90	3.07555	35	3.09167
1101	3.04179	46	3.05918	91	3.07591	36	3.09202
02	3.04218	47	3.05956	92	3.07628	37	3.09237
03	3.04258	48	3.05994	93	3.07664	38	3.09272
04	3.04297	49	3.06032	94	3.07700	39	3.09307
05	3.04336	50	3.06070	95	3.07737	40	3.09342
06	3.04376	31	3.06108	96	3.07773	41	3.09377
07	3.04415	52	3.06145	97	3.07809	42	3.09412
08	3.04454	53	3.06183	98	3.07846	43	3.09447
09	3.04493	54	3.06221	99	3.07882	44	3.09482
10	3.04532	55	3.06258	1200	3.07918	45	3.09517
11	3.04571	56	3.06296	1201	3.07954	46	3.09552
12	3.04610	57	3.06333	02	3.07990	47	3.09587
13	3.04650	58	3.06371	03	3.08027	48	3.09621
14	3.04689	59	3.06408	04	3.08063	49	3.09656
15	3.04727	60	3.06446	05	3.08099	50	3.09691
16	3.04766	61	3.06483	06	3.08135	51	3.09726
17	3.04805	62	3.06521	07	3.08171	52	3.09760
18	3.04844	63	3.06558	08	3.08207	53	3.09795
19	3.04883	64	3.06595	09	3.08243	54	3.09830
20	3.04922	65	3.06633	10	3.08279	55	3.09864
21	3.04961	66	3.06670	11	3.08314	56	3.09899
22	3.04999	67	3.06707	12	3.08350	57	3.09934
23	3.05038	68	3.06744	13	3.08386	58	3.09968
24	3.05077	69	3.06781	14	3.08422	59	3.10003
25	3.05115	70	3.0681[illegible]	15	3.08458	60	3.10037

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
1261	3.10072	1306	3.11594	1351	3.13066	1396	3.14489
62	3.10106	07	3.11628	52	3.13098	97	3.14520
63	3.10140	08	3.11661	53	3.13130	98	3.14551
64	3.10175	09	3.11694	54	3.13162	99	3.14582
65	3.10209	10	3.11727	55	3.13194	1400	3.14613
66	3.10243	11	3.11760	56	3.13226	1401	3.14644
67	3.10278	12	3.11793	57	3.13258	02	3.14675
68	3.10312	13	3.11826	58	3.13290	03	3.14706
69	3.10346	14	3.11860	59	3.13322	04	3.14737
70	3.10380	15	3.11893	60	3.13354	05	3.14768
71	3.10415	16	3.11926	61	3.13386	06	3.14799
72	3.10449	17	3.11959	62	3.13418	67	3.14829
73	3.10483	18	3.11992	63	3.13450	08	3.14860
74	3.10517	19	3.12024	64	3.13481	09	3.14891
75	3.10551	20	3.12057	65	3.13513	10	3.14922
76	3.10585	21	3.12090	66	3.13545	11	3.14953
77	3.10619	22	3.12123	67	3.13577	12	3.14983
78	3.10653	23	3.12156	68	3.13609	13	3.15014
79	3.10687	24	3.12189	69	3.13640	14	3.15045
80	3.10721	25	3.12222	70	3.13672	15	3.15076
81	3.10755	26	3.12254	71	3.13704	16	3.15106
82	3.10789	27	3.12287	72	3.13735	17	3.15137
83	3.10823	28	3.12320	73	3.13767	18	3.15168
84	3.10857	29	3.12353	74	3.13799	19	3.15198
85	3.10890	30	3.12385	75	3.13830	20	3.15229
86	3.10924	31	3.12418	76	3.13862	21	3.15259
87	3.10958	32	3.12450	77	3.13893	22	3.15290
88	3.10992	33	3.12483	78	3.13925	23	3.15320
89	3.11025	34	3.12516	79	3.13956	24	3.15351
90	3.11059	35	3.12548	80	3.13988	25	3.15381
91	3.11093	36	3.12581	81	3.14019	26	3.15412
92	3.11126	37	3.12613	82	3.14051	27	3.15442
93	3.11160	38	3.12646	83	3.14082	28	3.15473
94	3.11193	39	3.12678	84	3.14114	29	3.15503
95	3.11227	40	3.12710	85	3.14145	30	3.15534
96	3.11261	41	3.12743	86	3.14176	31	3.15564
97	3.11294	42	3.12775	87	3.14208	32	3.15594
98	3.11327	43	3.12808	88	3.14239	33	3.15625
99	3.11361	44	3.12840	89	3.14270	34	3.15655
1300	3.11394	45	3.12872	90	3.14301	35	3.15685
1301	3.11428	46	3.12905	91	3.14333	36	3.15715
02	3.11461	47	3.12937	92	3.14364	37	3.15746
03	3.11494	48	3.12969	93	3.14395	38	3.15776
04	3.11528	49	3.13001	94	3.14426	39	3.15806
05	3.11561	50	3.13033	95	3.14457	40	3.15836

N.	*Logar.*	*N.*	*Logar.*	*N.*	*Logar.*	*N.*	*Logar.*
1441	3.15866	1486	3.17202	1531	3.18498	1576	3.19756
42	3.15897	87	3.17231	32	3.18526	77	3.19783
43	3.15927	88	3.17260	33	3.18554	78	3.19811
44	3.15957	89	3.17289	34	3.18583	79	3.19838
45	3.15987	90	3.17319	35	3.18611	80	3.19866
46	3.16017	91	3.17348	36	3.18639	81	3.19893
47	3.16047	92	3.17377	37	3.18667	82	3.19921
48	3.16077	93	3.17406	38	3.18696	83	3.19948
49	3.16107	94	3.17435	39	3.18724	84	3.19976
50	3.16137	95	3.17464	40	3.18752	85	3.20003
51	3.16167	96	3.17493	41	3.18780	86	3.20030
52	3.16197	97	3.17522	42	3.18808	87	3.20058
53	3.16227	98	3.17551	43	3.18837	88	3.20085
54	3.16256	99	3.17580	44	3.18865	89	3.20112
55	3.16286	1500	3.17609	45	3.18893	90	3.20140
56	3.16316	1501	3.17638	46	3.18921	91	3.20167
57	3.16346	02	3.17667	47	3.18949	92	3.20194
58	3.16376	03	3.17696	48	3.18977	93	3.20222
59	3.16406	04	3.17725	49	3.19005	94	3.20249
60	3.16435	05	3.17754	50	3.19033	95	3.20276
61	3.16465	06	3.17783	51	3.19061	96	3.20303
62	3.16495	07	3.17811	52	3.19089	97	3.20330
63	3.16524	08	3.17840	53	3.19117	98	3.20358
64	3.16554	09	3.17869	54	3.19145	99	3.20385
65	3.16584	10	3.17898	55	3.19173	1600	3.20412
66	3.16613	11	3.17926	56	3.19201	1601	3.20439
67	3.16643	12	3.17955	57	3.19229	02	3.20466
68	3.16673	13	3.17984	48	3.19257	03	3.20493
69	3.16702	14	3.18013	59	3.19285	04	3.20520
70	3.16732	15	3.18041	60	3.19312	05	3.20548
71	3.16761	16	3.18070	61	3.19340	c6	3.20575
72	3.16791	17	3.18099	62	3.19368	07	3.20602
73	3.16820	18	3.18127	63	3.19396	08	3.20629
74	3.16850	19	3.18156	64	3.19424	09	3.20656
75	3.16879	20	3.18184	65	3.19451	10	3.20683
76	3.16909	21	3.18213	66	3.19479	11	3.20710
77	3.16938	22	3.18241	57	3.19507	12	3.20737
78	3.16967	23	3.18270	68	3.19535	13	3.20763
79	3.16997	24	3.18299	69	3.19562	14	3.20790
80	3.17026	25	3.18327	70	3.19590	15	3.20817
81	3.17056	20	3.18355	71	3.19618	16	3.20844
82	3.17085	27	3.18384	72	3.19645	17	3.20871
83	3.17114	28	3.18412	73	3.19673	18	3.20898
84	3.17143	29	3.18441	74	3.19700	19	3.20925
85	2.17173	30	3.18469	75	3.19728	20	3.20952

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
1621	3.20978	1666	3.22168	1711	3.23325	1756	3.24452
22	3.21005	67	3.22194	12	3.23350	57	3.24477
23	3.21032	68	3.22220	13	3.23376	58	3.24502
24	3.21059	69	3.22246	14	3.23401	59	3.24527
25	3.21085	70	3.22272	15	3.23426	60	3.24551
26	3.21112	71	3.22298	16	3.23452	61	3.24576
27	3.21139	72	3.22324	17	3.23477	62	3.24601
28	3.21165	73	3.22350	18	3.23502	63	3.24625
29	3.21192	74	3.22376	19	3.23528	64	3.24650
30	3.21219	75	3.2240	20	3.23553	65	3.24674
31	3.21245	76	3.22427	21	3.23578	66	3.24699
32	3.21272	77	3.22453	22	3.23603	67	3.24724
33	3.21299	78	3.22479	23	3.23629	68	3.24748
34	3.21325	79	3.22505	24	3.23654	69	3,24773
35	3.21352	80	3.22531	25	3.23679	70	3.24797
36	3.21378	81	3.22557	26	3.23704	71	3.24822
37	3.21405	82	3.22583	27	3.23729	72	3.24846
38	3.21431	83	3.22608	28	3.23754	73	3.24871
39	3.21458	84	3.22634	29	3.23780	74	3.24895
40	3.21484	85	3.22660	30	3.23805	75	3.24920
41	3.21511	86	3.22686	31	3.23830	76	3.24944
42	3.21537	87	3.22712	32	3.23855	77	3.24969
43	3.21564	88	3.22737	33	3.23880	78	3.24993
44	3.21590	89	3.22763	34	3.23905	79	3.25018
45	3.21617	90	3.22789	35	3.23930	80	3.25042
46	3.21643	91	3.22814	36	3.23955	81	3.25066
47	3.21669	92	3.22840	37	3.23980	82	3.25091
48	3.21696	93	3.22866	38	3.24005	83	3.25115
49	3.21722	94	3.22891	39	3.24030	84	3.25139
50	3.21748	95	3.22917	40	3.24055	85	3.25164
51	3.21775	96	3.22943	41	3.24080	86	3.25188
52	3.21801	97	3.22968	42	3.24105	87	3.25212
53	3.21827	98	3.22994	43	3.24130	88	3.25237
54	3.21854	99	3.23019	44	3.24155	89	3.25261
55	3.21880	1700	3.23045	45	3.24180	90	3.25285
56	3.21906	1701	3.23070	46	3.24204	91	3.25310
47	3.21932	02	3.23096	47	3.24229	92	3.25334
58	3.21958	03	3.23121	48	3.24254	93	3.25358
59	3.21985	04	3.23147	49	3.24279	94	3.25382
60	3.22011	05	3.23172	50	3.24304	95	3.25406
61	3.22037	06	3.23198	51	3.24329	96	3.25431
62	3.22063	07	3.23223	52	3.24353	97	3.25455
63	3.22089	08	3.23249	53	3.24378	98	3.25479
64	3.22115	09	3.23274	54	3.24403	99	3.25503
65	3.22141	10	3.23300	55	3.24428	800	3.25527

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
1801	3.25551	1846	3.26623	1891	3.27669	1936	3.28691
02	3.25575	47	3.26647	92	3.27692	37	3.28713
03	3.25600	48	3.26670	93	3.27715	38	3.28735
04	3.25624	49	3.26694	94	3.27738	39	3.28758
05	3.25648	50	3.26717	95	3.27761	40	3.28780
06	3.25672	51	3.26741	96	3.27784	41	3.28803
07	3.25696	52	3.26764	97	3.27807	42	3.28825
08	3.25720	53	3.26788	98	3.27830	43	3.28847
09	3.25744	54	3.26811	99	3.27853	44	3.28870
10	3.25768	55	3.26834	1900	3.27875	45	3.28892
11	3.25792	56	3.26858	1901	3.27898	46	3.28914
12	3.25816	57	3.26881	02	3.27921	47	3.28937
13	3.25840	58	3.26905	03	3.27944	48	3.28959
14	3.25864	59	3.26928	04	3.27967	49	3.28981
15	3.25888	60	3.26951	05	3.27990	50	3.29003
16	3.25912	61	3.26975	06	3.28012	51	3.29026
17	3.25935	62	3.26998	07	3.28035	52	3.29048
18	3.25960	63	3.27021	08	3.28058	53	3.29070
19	3.25983	64	3.27045	09	3.28081	54	3.29092
20	3.26007	65	3.27068	10	3.28103	55	3.29115
21	3.26031	66	3.27091	11	3.28126	56	3.29137
22	3.26055	67	3.27114	12	3.28149	57	3.29159
23	3.26079	68	3.27138	13	3.28172	58	3.29181
24	3.26102	69	3.27161	14	3.28194	59	3.29203
25	3.26126	70	3.27184	15	3.28217	60	3.29226
26	3.26150	71	3.27207	16	3.28240	61	3.29248
27	3.26174	72	3.27231	17	3.28262	62	3.29270
28	3.26198	73	3.27254	18	3.28285	63	3.29292
29	3.26221	74	3.27277	19	3.28308	64	3.29314
30	3.26245	75	3.27300	20	3.28330	65	3.29336
31	3.26269	76	3.27323	21	3.28353	66	3.29358
32	3.26293	77	3.27346	22	3.28375	67	3.29380
33	3.26316	78	3.27370	23	3.28398	68	3.29403
34	3.26340	79	3.27393	24	3.28421	69	3.29425
35	3.26364	80	3.27416	25	3.28443	70	3.29447
36	3.26387	81	3.27439	26	3.28466	71	3.29469
37	3.26411	82	3.27462	27	3.28488	72	3.29491
38	3.26435	83	3.27485	28	3.28511	73	3.29513
39	3.26458	84	3.27508	29	3.28533	74	3.29535
40	3.26482	85	3.27531	30	3.28556	75	3.29557
41	3.26505	86	3.27554	31	3.28578	76	3.29579
42	3.26529	87	3.27577	32	3.28601	77	3.29601
43	3.26553	88	3.27600	33	3.28623	78	3.29623
44	3.26576	89	3.27623	34	3.28646	79	3.29645
45	3.26600	90	3.27646	35	3.28668	80	3.29667

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
1981	3.29688	2026	3.30664	2071	3.31618	2116	3.32552
82	3.29710	27	3.30685	72	3.31639	17	3.32572
83	3.29732	28	3.30707	73	3.31660	18	3.32593
84	3.29754	29	3.30728	74	3.31681	19	3.32613
85	3.29776	30	3.30750	75	3.31702	20	3.32634
86	3.29798	31	3.30771	76	3.31723	21	3.32654
87	3.29820	32	3.30792	77	3.31744	22	3.32675
88	3.29842	33	3.30814	78	3.31765	23	3.32695
89	3.29863	34	3.30835	79	3.31785	24	3.32715
90	3.29885	35	3.30856	80	3.31806	25	3.32736
91	3.29907	36	3.30878	81	3.31827	26	3.32756
92	3.29929	37	3.30899	82	3.31848	27	3.32777
93	3.29951	38	3.30920	83	3.31869	28	3.32797
94	3.29973	39	3.30942	84	3.31890	29	3.32818
95	3.29994	40	3.30963	85	3.31911	30	3.32838
96	3.30016	41	3.30984	86	3.31931	31	3.32858
97	3.30038	42	3.31006	87	3.31952	32	3.32879
98	3.30060	43	3.31027	88	3.31973	33	3.32899
99	3.30081	44	3.31048	89	3.31994	34	3.32919
2000	3.30103	45	3.31069	90	3.32015	35	3.32940
2001	3.30125	46	3.31091	91	3.32035	36	3.32960
02	3.30146	47	3.31112	92	3.32056	37	3.32980
03	3.30168	48	3.31133	93	3.32077	38	3.33001
04	3.30190	49	3.31154	94	3.32098	39	3.33021
05	3.30211	50	3.31175	95	3.32118	40	3.33041
06	3.30233	51	3.31197	96	3.32139	41	3.33062
07	3.30255	52	3.31218	97	3.32160	42	3.33082
08	3.30276	53	3.31239	98	3.32181	43	3.33102
09	3.30298	54	3.31260	99	3.32201	44	3.33122
10	3.30320	55	3.31281	2100	3.32222	45	3.33143
11	3.30341	56	3.31302	2101	3.32243	46	3.33163
12	3.30363	57	3.31323	02	3.32264	47	3.33183
13	3.30384	58	3.31345	03	3.32284	48	3.33203
14	3.30406	59	3.31366	04	3.32305	49	3.33224
15	3.30428	60	3.31387	05	3.32325	50	3.33244
16	3.30449	61	3.31408	06	3.32346	51	3.33264
17	3.30471	62	3.31429	07	3.32366	52	3.33284
18	3.30492	63	3.31450	08	3.32387	53	3.33304
19	3.30514	64	3.31471	09	3.32408	54	3.33325
20	3.30535	65	3.31492	10	3.32428	55	3.33345
21	3.30557	66	3.31513	11	3.32449	56	3.33365
22	3.30578	67	3.31534	12	3.32469	57	3.33385
23	3.30600	68	3.31555	13	3.32490	58	3.33405
24	3.30621	69	3.31576	14	3.32511	59	3.33425
25	2.30643	70	3.31597	15	3.32531	60	3.33445

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
2161	3.33465	2206	3.34361	2251	3.35238	2296	3.36097
62	3.33486	07	3.34380	52	3.35257	97	3.36116
63	3.33506	08	3.34400	53	3.35276	98	3.36135
64	3.33526	09	3.34420	54	3.35295	99	3.36154
65	3.33546	10	3.34439	55	3.35315	2300	3.36173
66	3.33566	11	3.34459	56	3.35334	2301	3.36192
67	3.33586	12	3.34479	57	3.35353	02	3.36211
68	3.33606	13	3.34498	58	3.35372	03	3.36229
69	3.33626	14	3.34518	59	3.35392	04	3.36248
70	3.33646	15	3.34537	60	3.35411	05	3.36267
71	3.33666	16	3.34557	61	3.35430	06	3.36286
72	3.33686	17	3.34577	62	3.35449	07	3.36305
73	3.33706	18	3.34596	63	3.35468	08	3.36324
74	3.33726	19	3.34616	64	3.35488	09	3.36342
75	3.33746	20	3.34635	65	3.35507	10	3.36361
76	3.33766	21	3.34655	66	3.35526	11	3.36380
77	3.33786	22	3.34674	67	3.35545	12	3.36399
78	3.33806	23	3.34694	68	3.35564	13	3.36418
79	3.33826	24	3.34713	69	3.35583	14	3.36436
80	3.33846	25	3.34733	70	3.35603	15	3.36455
81	3.33866	26	3.34753	71	3.35622	16	3.36474
82	3.33885	27	3.34772	72	3.35641	17	3.36493
83	3.33905	28	3.34792	73	3.35660	18	3.36511
84	3.33925	29	3.34811	74	3.35679	19	3.36530
85	3.33945	30	3.34830	75	3.35698	20	3.36549
86	3.33965	31	3.34850	76	3.35717	21	3.36568
87	3.33985	32	3.34869	77	3.35736	22	3.36586
88	3.34005	33	3.34889	78	3.35755	23	3.36605
89	3.34025	34	3.34908	79	3.35774	24	3.36624
90	3.34044	35	3.34928	80	3.35793	25	3.36642
91	3.34064	36	3.34947	81	3.35813	26	3.36661
92	3.34084	37	3.34967	82	3.35832	27	3.36680
93	3.34104	38	3.34986	83	3.35851	28	3.36698
94	3.34124	39	3.35005	84	3.35870	29	3.36717
95	3.34143	40	3.35025	85	3.35889	30	3.36736
96	3.34163	41	3.35044	86	3.35908	31	3.36754
97	3.34183	42	3.35064	87	3.35927	32	3.36773
98	3.34203	43	3.35083	88	3.35946	33	3.36791
99	3.34223	44	3.35102	89	3.35965	34	3.36810
2200	3.34242	45	3.35122	90	3.35984	35	3.36829
2201	3.34262	46	3.35141	91	3.36003	36	3.36847
02	3.34282	47	3.35160	92	3.36021	37	3.36866
03	3.34301	48	3.35180	93	3.36040	38	3.36884
04	3.34321	49	3.35199	94	3.36059	39	3.36903
05	3.34341	50	3.35218	95	3.36078	40	3.36922

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
2341	3.36940	2386	3.37767	2431	3.38579	2476	3.39375
42	3.36959	87	3.37785	32	3.38596	77	3.39393
43	3.36977	88	3.37803	33	3.38614	78	3.39410
44	3.36996	89	3.37822	34	3.38632	79	3.39428
45	3.37014	90	3.37840	35	3.38650	80	3.39449
46	3.37033	91	3.37858	36	3.38668	81	3.39463
47	3.37051	92	3.37876	37	3.38686	82	3.39480
48	3.37070	93	3.37894	38	3.38703	83	3.39498
49	3.37088	94	3.37912	39	3.38721	84	3.39515
50	3.37107	95	3.37931	40	3.38739	85	3.39533
51	3.37125	96	3.37949	41	3.38757	86	3.39550
52	3.37144	97	3.37967	42	3.38775	87	3.39568
53	3.37162	98	3.37985	43	3.38792	88	3.39585
54	3.37181	99	3.38003	44	3.38810	89	3.39602
55	3.37199	2400	3.38021	45	3.38828	90	3.39620
56	3.37218	2401	3.38039	46	3.38846	91	3.39637
57	3.37236	02	3.38057	47	3.38863	92	3.39655
58	3.37254	03	3.38075	48	3.38881	93	3.39672
59	3.37273	04	3.38093	49	3.38899	94	3.39690
60	3.37291	05	3.38112	50	3.38917	95	3.39707
61	3.37310	06	3.38130	51	3.38934	96	3.39724
62	3.37328	07	3.38148	52	3.38952	97	3.39741
63	3.37346	08	3.38166	53	3.38970	98	3.39759
64	3.3[illegible]	09	3.38184	54	3.38987	99	3.39777
65	3.37383	10	3.38202	55	3.39005	2500	3.39794
66	3.37401	11	3.38220	56	3.39022	2501	3.39811
67	3.37420	12	3.38238	57	3.39041	02	3.39829
68	3.37438	13	3.38256	58	3.39058	03	3.39846
69	3.37457	14	3.38274	59	3.39076	04	3.39863
70	3.37475	15	3.38292	60	3.39094	05	3.39881
71	3.37493	16	3.38310	61	3.39111	06	3.39898
72	3.37511	17	3.38328	62	3.39129	07	3.39915
73	3.37530	18	3.38346	63	3.39146	08	3.39933
74	3.37548	19	3.38364	64	3.39164	09	3.39950
75	3.37566	20	3.38382	65	3.39182	10	3.39967
76	3.37585	21	3.38399	66	3.39199	11	3.39985
77	3.37603	22	3.38417	67	3.39217	12	3.40002
78	3.37621	23	3.38435	68	3.39235	13	3.40019
79	3.37639	24	3.38453	69	3.39252	14	3.40037
80	3.37658	25	3.38471	70	3.39270	15	3.40054
81	3.37676	26	3.38489	71	3.39287	16	3.40071
82	3.37694	27	3.38507	72	3.39305	17	3.40088
83	3.37712	28	3.38525	73	3.39322	18	3.40106
84	3.37731	29	3.38543	74	3.39340	19	3.40123
85	3.37749	30	3.38561	75	3.39358	20	3.40140

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
2521	3.40157	2566	3.40926	2611	3.41681	2656	3.42423
22	3.40175	67	3.40943	12	3.41697	57	3.42439
23	3.40192	68	3.40960	13	3.41714	58	3.42456
24	3.40209	69	3.40976	14	3.41731	59	3.42472
25	3.40226	70	3.40993	15	3.41747	60	3.42488
26	3.40243	71	3.41010	16	3.41764	61	3.42504
27	3.40261	72	3.41027	17	3.41780	62	3.42521
28	3.40278	73	3.41044	18	3.41797	63	3.42537
29	3.40295	74	3.41061	19	3.41814	64	3.42553
30	3.40312	75	3.41078	20	3.41830	65	3.42570
31	3.40329	76	3.41095	21	3.41847	66	3.42586
32	3.40346	77	3.41111	22	3.41863	67	3.42602
33	3.40364	78	3.41128	23	3.41880	68	3.42619
34	3.40381	79	3.41145	24	3.41896	69	3.42635
35	3.40398	80	3.41162	25	3.41913	70	3.42651
36	3.40415	81	3.41179	26	3.41929	71	3.42667
37	3.40432	82	3.41196	27	3.41946	72	3.42684
38	3.40449	83	3.41212	28	3.41963	73	3.42700
39	3.40466	84	3.41229	29	3.41979	74	3.42716
40	3.40483	85	3.41246	30	3.41996	75	3.42732
41	3.40500	86	3.41263	31	3.42012	76	3.42749
42	3.40518	87	3.41280	32	3.42029	77	3.42765
43	3.40535	88	3.41296	33	3.42045	78	3.42781
44	3.40552	89	3.41313	34	3.42062	79	3.42797
45	3.40569	90	3.41330	35	3.42078	80	3.42813
46	3.40586	91	3.41347	36	3.42095	81	3.42830
47	3.40603	92	3.41364	37	3.42111	82	3.42846
48	3.40620	93	3.41380	38	3.42127	83	3.42862
49	3.40637	94	3.41397	39	3.42144	84	3.42878
50	3.40654	95	3.41414	40	3.42160	85	3.42894
51	3.40671	96	3.41430	41	3.42177	86	3.42911
52	3.40688	97	3.41447	42	3.42193	87	3.42927
53	3.40705	98	3.41464	43	3.42210	88	3.42943
54	3.40722	99	3.41481	44	3.42226	89	3.42959
55	3.40739	2600	3.41497	45	3.42243	90	3.42975
56	3.40756	2601	3.41514	46	3.42259	91	3.42991
57	3.40773	02	3.41531	47	3.42275	92	3.43008
58	3.40790	03	3.41547	48	3.42292	93	3.43024
59	3.40807	04	3.41564	49	3.42308	94	3.43040
60	3.40824	05	3.41581	50	3.42325	95	3.43056
61	3.40841	06	3.41597	51	3.42341	96	3.43072
62	3.40858	07	3.41614	52	3.42357	97	3.43088
63	3.40875	08	3.41631	53	3.42374	98	3.43104
64	3.40892	09	3.41647	54	3.42390	99	3.43120
65	3.40909	10	3.41664	55	3.42406	2700	3.43136

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
2701	3.43152	2746	3.43870	2791	3.44576	2836	3.45271
02	3.43169	47	3.43886	92	3.44592	37	3.45286
03	3.43185	48	3.43902	93	3.44607	38	3.45301
04	3.43201	49	3.43917	94	3.44623	39	3.45317
05	3.43217	50	3.43933	95	3.44638	40	3.45332
06	3.43233	51	3.43949	96	3.44654	41	3.45347
07	3.43249	52	3.43965	97	3.44669	42	3.45362
08	3.43265	53	3.43981	98	3.44685	43	3.45378
09	3.43281	54	3.43996	99	3.44700	44	3.45393
10	3.43297	55	3.44012	2800	3.44716	45	3.45408
11	3.43313	56	3.44028	01	3.44731	46	3.45423
12	3.43329	57	3.44044	02	3.44747	47	3.45439
13	3.43345	58	3.44059	03	3.44762	48	3.45454
14	3.43361	59	3.44075	04	3.44778	49	3.45469
15	3.43377	60	3.44091	05	3.44793	50	3.45484
16	3.43393	61	3.44107	06	3.44809	51	3.45500
17	3.43409	62	3.44122	07	3.44824	52	3.45515
18	3.43425	63	3.44138	08	3.44840	53	3.45530
19	3.43441	64	3.44154	09	3.44855	54	3.45545
20	3.43457	65	3.44170	10	3.44871	55	3.45561
21	3.43473	66	3.44185	11	3.44886	56	3.45576
22	3.43489	67	3.44201	12	3.44902	57	3.45591
23	3.43505	68	3.44217	13	3.44917	58	3.45606
24	3.43521	69	3.44232	14	3.44932	59	3.45621
25	3.43537	70	3.44248	15	3.44948	60	3.45637
26	3.43553	71	3.44264	16	3.44963	61	3.45652
27	3.43569	72	3.44279	17	3.44979	62	3.45667
28	3.43584	73	3.44295	18	3.44994	63	3.45682
29	3.43600	74	3.44311	19	3.45010	64	3.45697
30	3.43616	75	3.44326	20	3.45025	65	3.45712
31	3.43632	76	3.44342	21	3.45040	66	3.45728
32	3.43648	77	3.44358	22	3.45056	67	3.45743
33	3.43664	78	3.44373	23	3.45071	68	3.45758
34	3.43680	79	3.44389	24	3.45086	69	3.45773
35	3.43696	80	3.44404	25	3.45102	70	3.45788
36	3.43712	81	3.44420	26	3.45117	71	3.45803
37	3.43727	82	3.44436	27	3.45132	72	3.45818
38	3.43743	83	3.44451	28	3.45148	73	3.45834
39	3.43759	84	3.44467	29	3.45163	74	3.45849
40	3.43775	85	3.44483	30	3.45179	75	3.45864
41	3.43791	86	3.44498	31	3.45194	76	3.45879
42	3.43807	87	3.44514	32	3.45209	77	3.45894
43	3.43823	88	3.44529	33	3.45225	78	3.45909
44	3.43838	89	3.44545	34	3.45240	79	3.45924
45	3.43854	90	3.44560	35	3.45255	80	[illegible]

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
2881	3.45954	2926	3.46627	2971	3.47290	3016	3.47943
82	3.45969	27	3.46642	72	3.47305	17	3.47958
83	3.45984	28	3.46657	73	3.47319	18	3.47972
84	3.46000	29	3.46672	74	3.47334	19	3.47986
85	3.46015	30	3.46687	75	3.47349	20	3.48001
86	3.46030	31	3.46702	76	3.47363	21	3.48015
87	3.46045	32	3.46716	77	3.47378	22	3.48029
88	3.46060	33	3.46731	78	3.47392	23	3.48044
89	3.46075	34	3.46746	79	3.47407	24	3.48058
90	3.46090	35	3.46761	80	3.47422	25	3.48073
91	3.46105	36	3.46776	81	3.47436	26	3.48087
92	3.46120	37	3.46790	82	3.47451	27	3.48101
93	3.46135	38	3.46805	83	3.47465	28	3.48116
94	3.46150	39	3.46820	84	3.47480	29	3.48130
95	3.46165	40	3.46835	85	3.47494	30	3.48144
96	3.46180	41	3.46850	86	3.47509	31	3.48159
97	3.46195	42	3.46864	87	3.47524	32	3.48173
98	3.46210	43	3.46879	88	3.47538	33	3.48187
99	3.46225	44	3.46894	89	3.47553	34	3.48202
2900	3.46240	45	3.46909	90	3.47567	35	3.48216
2901	3.46255	46	3.46923	91	3.47582	36	3.48230
02	3.46270	47	3.46938	92	3.47596	37	3.48244
03	3.46285	48	3.46953	93	3.47611	38	3.48259
04	3.46300	49	3.46967	94	3.47625	39	3.48273
05	3.46315	50	3.46982	95	3.47640	40	3.48287
06	3.46330	51	3.46997	96	3.47654	41	3.48302
07	3.46345	52	3.47012	97	3.47669	42	3.48316
08	3.46360	53	3.47026	98	3.47683	43	3.48330
09	3.46374	54	3.47041	99	3.47698	44	3.48344
10	3.46389	55	3.47056	3000	3.47712	45	3.48359
11	3.46404	56	3.47070	3001	3.47727	46	3.48373
12	3.46419	57	3 47085	02	3.47741	47	3.48387
13	3.46434	58	3.47100	03	3.47756	48	3.48402
14	3.46449	59	3.47115	04	3.47770	49	3.48416
15	3.46464	60	3.47129	05	3.47784	50	3 48430
16	3.46479	61	3.47144	06	3.47799	51	3.48444
17	3.46494	62	3.47159	07	3.47813	52	3.48458
18	3.46509	63	3.47173	08	3.47828	53	3.48473
19	3.46523	64	3.47188	09	3.47842	54	3.48487
20	3.46538	65	3.47202	10	3.47857	55	3.48501
21	3.46553	66	3.47217	11	3.47871	56	3.48515
22	3.46568	67	3.47232	12	3.47886	57	3.48530
23	3.46583	68	3.47246	13	3.47900	58	3.48544
24	3.46598	69	3.47261	14	3.47914	59	3.48558
25	2.46613	70	3.47276	15	3.47929	60	3.48572

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
3061	3.48586	3106	3.49220	3151	3.49845	3196	3.50461
62	3.48601	07	3.49234	52	3.49859	97	3.50474
63	3.48615	08	3 49248	53	3 49872	98	3.50488
64	3.48629	09	3.49262	54	3.49886	99	3.50501
65	3.48643	10	3.49276	55	3.49900	3200	3.50515
66	3.48657	11	3.49290	56	3.49914	3201	3.50529
67	3.48671	12	3.49304	57	3.49927	02	3.50542
68	3.48686	13	3.49318	58	3.49941	03	3 50556
69	3.48700	14	3.49332	59	3.49955	04	3.50569
70	3 48714	15	3.49346	60	3.4 969	05	3.50583
71	3.48728	16	3.49360	61	3.49982	06	3.50596
72	3.48742	17	3.49374	62	3.49996	07	3.50610
73	3.48756	18	3.49388	63	3.50010	08	3.50623
74	3.48770	19	3.49402	64	3.50024	09	3.50637
75	3.48785	20	3.49415	65	3.50037	10	3.50651
76	3.48799	21	3.49429	66	3.50051	11	3.50664
77	3.48813	22	3.49443	67	3.50065	12	3.50678
78	3.48827	23	3.49457	68	3.50079	13	3.50691
79	3.48841	24	3.49471	69	3.50092	14	3.50705
80	3.48855	25	3.49485	70	3.50106	15	3.50718
81	3.48869	26	3.49499	71	3.50120	16	3.50732
82	3.48883	27	3.49513	72	3.50133	17	3.50745
83	3.48897	28	3.49527	73	3.50147	18	3.50759
84	3.48911	29	3.49541	74	3.50161	19	3.50772
85	3.48926	30	3.49554	75	3.50174	20	3.50786
86	3.48940	31	3.49568	76	3.50188	21	3.50799
87	3.48954	32	3.49582	77	3.50202	22	3.50813
88	3.48968	33	3.49596	78	3.50215	23	3.50826
89	3.48982	34	3.49610	79	3.50229	24	3.50840
90	3.48996	35	3.49624	80	3.50243	25	3.50853
91	3.49010	36	3.49638	81	3.50256	26	3.50866
92	3.49024	37	3.49651	82	3.50270	27	3.50880
93	3.49038	38	3.49665	83	3.50284	28	3.50893
94	3.49052	39	3.49679	84	3.50297	29	3.50907
95	3.49066	40	3.49693	85	3.50311	30	3.50920
96	3.49080	41	3.49707	86	3.50325	31	3.50934
97	3.49094	42	3.49721	87	3.50338	32	3.50947
98	3.49108	43	3.49734	88	3.50352	33	3.50961
99	3.49122	44	3.49748	89	3.50365	34	3.50974
3100	3.49136	45	3.49762	90	3.50379	35	3.50987
3101	3.49150	46	3.49776	91	3.50393	36	3.51001
02	3.49164	47	3.49790	92	3.50406	37	3.51014
03	3.49178	48	3.49803	93	3.50420	38	3.51028
04	3.49192	49	3.49817	94	3.50433	39	3.51041
05	3.49206	50	3.49831	95	3.50447	40	3.51055

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
3241	3.51068	3286	3.51667	3331	3.52257	3376	3.52840
42	3.51081	87	3.51680	32	3.52271	77	3.52853
43	3.51095	88	3.51693	33	3.52284	78	3.52866
44	3.51108	89	3.51706	34	3.52297	79	3.52879
45	3.51121	90	3.51720	35	3.52310	80	3.52892
46	3.51135	91	3.51733	36	3.52323	81	3.52905
47	3.51148	92	3.51746	37	3.52336	82	3.52917
48	3.51162	93	3.51759	38	3.52349	83	3.52930
49	3.51175	94	3.51772	39	3.52362	84	3.52943
50	3.51188	95	3.51786	40	3.52375	85	3.52956
51	3.51202	96	3.51799	41	3.52388	86	3.52969
52	3.51215	97	3.51812	42	3.52401	87	3.52982
53	3.51228	98	3.51825	43	3.52414	88	3.52994
54	3.51242	99	3.51838	44	3.52427	89	3.53007
55	3.51255	3300	3.51851	45	3.52440	90	3.53020
56	3.51268	3301	3.51865	46	3.52453	91	3.53033
57	3.51282	02	3.51878	47	3.52466	92	3.53046
58	3.51295	03	3.51891	48	3.52479	93	3.53058
59	3.51308	04	3.51904	49	3.52492	94	3.53071
60	3.51322	05	3.51917	50	3.52504	95	3.53084
61	3.51335	06	3.51930	51	3.52517	96	3.53097
62	3.51348	07	3.51943	52	3.52530	97	3.53110
63	3.51362	08	3.51957	53	3.52543	98	3.53122
64	3.51375	09	3.51970	54	3.52556	99	3.53135
65	3.51388	10	3.51983	55	3.52569	3400	3.53148
66	3.51402	11	3.51996	56	3.52582	3401	3.53161
67	3.51415	12	3.52009	57	3.52595	02	3.53173
68	3.51428	13	3.52022	58	3.52608	03	3.53186
69	3.51441	14	3.52035	59	3.52621	04	3.53199
70	3.51455	15	3.52048	60	3.52634	05	3.53212
71	3.51468	16	3.52061	61	3.52647	06	3.53224
72	3.51481	17	3.52075	62	3.52660	07	3.53237
73	3.51495	18	3.52088	63	3.52673	08	3.53250
74	3.51508	19	3.52101	64	3.52686	09	3.53263
75	3.51521	20	3.52114	65	3.52699	10	3.53275
76	3.51534	21	3.52127	66	3.52711	11	3.53288
77	3.51548	22	3.52140	67	3.52724	12	3.53301
78	3.51561	23	3.52153	68	3.52737	13	3.53314
79	3.51574	24	3.52166	69	3.52750	14	3.53326
80	3.51587	25	3.52179	70	3.52763	15	3.53339
81	3.51601	26	3.52192	71	3.52776	16	3.53352
82	3.51614	27	3.52205	72	3.52789	17	3.53365
83	3.51627	28	3.52218	73	3.52802	18	3.53377
84	3.51640	29	3.52231	74	3.52815	19	3.53390
85	3.51654	30	3.52244	75	3.52827	20	3.53403

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
3421	3.53415	3466	3.53983	3511	3.54543	3556	3.55096
22	3.53428	67	3.53995	12	3.54555	57	3.55108
23	3.53441	68	3.54008	13	3.54568	58	3.55121
24	3.53453	69	3.54020	14	3.54580	59	3.55133
25	3.53466	70	3.54033	15	3.54593	60	3.55145
26	3.53479	71	3.54045	16	3.54605	61	3.55157
27	3.53491	72	3.54058	17	3.54617	62	3.55169
28	3.53504	73	3.54070	18	3.54630	63	3.55182
29	3.53517	74	3.54083	19	3.54642	64	3.55194
30	3.53529	75	3.54095	20	3.54654	65	3.55206
31	3.53542	76	3.54108	21	3.54667	66	3.55218
32	3.53555	77	3.54120	22	3.54679	67	3.55230
33	3.53567	78	3.54133	23	3.54691	68	3.55242
34	3.53580	79	3.54145	24	3.54704	69	3.55255
35	3.53593	80	3.54158	25	3.54716	70	3.55267
36	3.53605	81	3.54170	26	3.54728	71	3.55279
37	3.53618	82	3.54183	27	3.54741	72	3.55291
38	3.53631	83	3.54195	28	3.54753	73	3.55303
39	3.53643	84	3.54208	29	3.54765	74	3.55315
40	3.53656	85	3.54220	30	3.54777	75	3.55328
41	3.53668	86	3.54233	31	3.54790	76	3.55340
42	3.53681	87	3.54245	32	3.54802	77	3.55352
43	3.53694	88	3.54258	33	3.54814	78	3.55364
44	3.53706	89	3.54270	34	3.54827	79	3.55376
45	3.53719	90	3.54283	35	3.54839	80	3.55388
46	3.53732	91	3.54295	36	3.54851	81	3.55400
47	3.53744	92	3.54307	37	3.54864	82	3.55413
48	3.53757	93	3.54320	38	3.54876	83	3.55425
49	3.53769	94	3.54332	39	3.54888	84	3.55437
50	3.53782	95	3.54345	40	3.54900	85	3.55449
51	3.53795	96	3.54357	41	3.54913	86	3.55461
52	3.53807	97	3.54370	42	3.54925	87	3.55473
53	3.53820	98	3.54382	43	3.54937	88	3.55485
54	3.53832	99	3.54394	44	3.54949	89	3.55497
55	3.53845	3500	3.54407	45	3.54962	90	3.55509
56	3.53857	3501	3.54419	46	3.54974	91	3.55522
57	3.53870	02	3.54432	47	3.54986	92	3.55534
58	3.53883	03	3.54444	48	3.54998	93	3.55546
59	3.53895	04	3.54456	49	3.55011	94	3.55558
60	3.53908	05	3.54469	50	3.55023	95	3.55570
61	3.53920	06	3.54481	51	3.55035	96	3.55582
62	3.53933	07	3.54494	52	3.55047	97	3.55594
63	3.53945	08	3.54506	53	3.55060	98	3.55606
64	3.53958	09	3.54518	54	3.55072	99	3.55618
65	3.53970	10	3.54531	55	3.55084	3600	3.55630

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
3601	3.55642	3646	3.56182	3691	3.56714	3736	3.57241
02	3.55654	47	3.56194	92	3.56726	37	3.57252
03	3.55666	48	3.56205	93	3.56738	38	3.57264
04	3.55678	49	3.56217	94	3.56750	39	3.57276
05	3.55691	50	3.56229	95	3.56761	40	3.57287
06	3.55702	51	3.56241	96	3.56773	41	3.57299
07	3.55715	52	3.56253	97	3.56785	42	3.57310
08	3.55727	53	3.56265	98	3.56797	43	3.57322
09	3.55739	54	3.56277	99	3.56808	44	3.57334
10	3.55751	55	3.56289	3700	3.56820	45	3.57345
11	3.55763	56	3.56301	3701	3.56832	46	3.57357
12	3.55775	57	3.56313	02	3.56844	47	3.57368
13	3.55787	58	3.56324	03	3.56855	48	3.57380
14	3.55799	59	3.46336	04	3.56867	49	3.57392
15	3.55811	60	3.56348	05	3.56879	50	3.57403
16	3.55823	61	3.56360	06	3.56891	51	3.57415
17	3.55835	62	3.56372	07	3.56902	52	3.57426
18	3.55847	63	3.56384	08	3.56914	53	3.57438
19	3.55859	64	3.56396	09	3.56926	54	3.57449
20	3.55871	65	3.56407	10	3.56937	55	3.57461
21	3.55882	66	3.56419	11	3.56949	56	3.57473
22	3.55895	67	3.56431	12	3.56961	57	3.57484
23	3.55907	68	3.56443	13	3.56972	58	3.57496
24	3.55919	69	3.56455	14	3.56984	59	3.57507
25	3.55931	70	3.56467	15	3.56996	60	3.57519
26	3.55943	71	3.56478	16	3.57008	61	3.57530
27	3.55955	72	3.56490	17	3.57019	62	3.57542
28	3.55967	73	3.56502	18	3.57031	63	3.57553
29	3.55979	74	3.56514	19	3.57043	64	3.57565
30	3.55991	75	3.56526	20	3.57054	65	3.57577
31	3.56003	76	3.56538	21	3.57066	66	3.57588
32	3.56015	77	3.56549	22	3.57078	67	3.57600
33	3.56026	78	3.56561	23	3.57089	68	3.57611
34	3.56038	79	3.56573	24	3.57101	69	3.57623
35	3.56050	80	3.56585	25	3.57113	70	3.57634
36	3.56062	81	3.56597	26	3.57124	71	3.57646
37	3.56074	82	3.56608	27	3.57136	72	3.57657
38	3.56086	83	3.56620	28	3.57148	73	3.57669
39	3.56098	84	3.56632	29	3.57159	74	3.57680
40	3.56110	85	3.56644	30	3.57171	75	3.57692
41	3.56122	86	3.56656	31	3.57183	76	3.57703
42	3.56134	87	3.56667	32	3.57194	77	3.57715
43	3.56146	88	3.56679	33	3.57206	78	3.57726
44	3.56158	89	3.56691	34	3.57217	79	3.57738
45	3.56170	90	3.56703	35	3.57229	80	3.57749

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
3781	3.57761	3826	3.58275	3871	3.58782	3916	3 59284
82	3.57772	27	3.58286	72	3.58794	17	3.59295
83	3.57784	28	3.58297	73	3.58805	18	3.59306
84	3.57795	29	3.58309	74	3.58816	19	3.59318
85	3.57807	30	3.58320	75	3.58827	20	3.59329
86	3.57818	31	3.58331	76	3.58838	21	3.59340
87	3.57830	32	3.58343	77	3.58850	22	3.59351
88	3.57841	33	3.58354	78	3.58861	23	3.59362
89	3.57852	34	3.58365	79	3.58872	24	3.59373
90	3.57864	35	3.58377	80	3.58883	25	3.59384
91	3.57875	36	3.58388	81	3.58894	26	3.59395
92	3.57887	37	3.58399	82	3.58906	27	3.59406
93	3.57898	38	3.58411	83	3.58917	28	3.59417
94	3.57910	39	3.58422	84	3.58928	29	3.59428
95	3.57921	40	3.58433	85	3.58939	30	3.59439
96	3.57933	41	3.58444	86	3.58950	31	3.59450
97	3.57944	42	3.58456	87	3.58961	32	3.59461
98	3.57956	43	3.58467	88	3.58973	33	3.59472
99	3.57967	44	3.58478	89	3.58984	34	3.59483
3800	3.57978	45	3.58490	90	3.58995	35	3.59494
3801	3.57990	46	3.58501	91	3.59006	36	3.59506
02	3.58001	47	3.58512	92	3.59017	37	3.59517
03	3.58013	48	3.58524	93	3.59028	38	3.59528
04	3.58024	49	3.58535	94	3.59040	39	3.59539
05	3.58035	50	3.58546	95	3.59051	40	3.59550
06	3.58047	51	3.58557	96	3.59062	41	3.59561
07	3.58058	52	3.58569	97	3.59073	42	3.59572
08	3.58070	53	3.58580	98	3.59084	43	3.59583
09	3.58081	54	3.58591	99	3.59095	44	3.59594
10	3.58093	55	3.58602	3900	3.59106	45	3.59605
11	3.58104	56	3.58614	3901	3.59118	46	3.59616
12	3.58115	47	3.58625	02	3.59129	47	3.59627
13	3.58127	58	3.58636	03	3.59140	48	3.59638
14	3.58138	59	3.58647	04	3.59151	49	3.59649
15	3.58149	60	3.58659	05	3.59162	50	3.59660
16	3.58161	61	3.58670	06	3.59173	51	3.59671
17	3.58172	62	3.58681	07	3.59184	52	3.59682
18	3.58184	63	3.58692	08	3.59195	53	3.59693
19	3.58195	64	3.58704	09	3.59207	54	3.59704
20	3.58206	65	3.58715	10	3.59218	55	3.59715
21	3.58218	66	3.58726	11	3.59229	56	3.59726
22	3.58229	67	3.58737	12	3.59240	57	3.59737
23	3.58240	68	3.58749	13	3.59251	58	3.59748
24	3.58252	69	3.58760	14	3.59262	59	3.59759
25	3.58263	70	3.58771	15	3.59273	60	3.59770

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
3961	3.59780	4006	3.60271	4051	3.60756	4096	3.61236
62	3.59791	07	3.60282	52	3.60767	97	3.61247
63	3.59802	08	3.60293	53	3.60778	98	3.61257
64	3.59813	09	3.60304	54	3.60788	99	3.61268
65	3.59824	10	3.60314	55	3.60799	4100	3.61278
66	3.59835	11	3.60325	56	3.60810	4101	3.61289
67	3.59846	12	3.60336	57	3.60821	02	3.61300
68	3.59857	13	3.60347	58	3.60831	03	3.61310
69	3.59868	14	3.60358	59	3.60842	04	3.61321
70	3.59879	15	3.60369	60	3.60853	05	3.61331
71	3.59890	16	3.60379	61	3.60863	06	3.61342
72	3.59901	17	3.60390	62	3.60874	07	3.61352
73	3.59912	18	3.60401	63	3.60885	08	3.61363
74	3.59923	19	3.60412	64	3.60895	09	3.61374
75	3.59934	20	3.60423	65	3.60906	10	3.61384
76	3.59945	21	3.60433	66	3.60917	11	3.61395
77	3.59956	22	3.60444	67	3.60927	12	3.61405
78	3.59966	23	3.60455	68	3.60938	13	3.61416
79	3.59977	24	3.60466	69	3.60949	14	3.61426
80	3.59988	25	3.60477	70	3.60959	15	3.61437
81	3.59999	26	3.60487	71	3.60970	16	3.61448
82	3.60010	27	3.60498	72	3.60981	17	3.61458
83	3.60021	28	3.60509	73	3.60991	18	3.61469
84	3.60032	29	3.60520	74	3.61002	19	3.61479
85	3.60043	30	3.60531	75	3.61013	20	3.61490
86	3.60054	31	3.60541	76	3.61023	21	3.61500
87	3.60065	32	3.60552	77	3.61034	22	3.61511
88	3.60076	33	3.60563	78	3.61045	23	3.61521
89	3.60086	34	3.66574	79	3.61055	24	3.61532
90	3.60097	35	3.66584	80	3.61066	25	3.61542
91	3.60108	36	3.60595	81	3.61077	26	3.61553
92	3.60119	37	3.60606	82	3.61087	27	3.61563
93	3.60130	38	3.60617	83	3.61098	28	3.61574
94	3.60141	39	3.60627	84	3.61109	29	3.61584
95	3.60152	40	3.60638	85	3.61119	30	3.61595
96	3.60163	41	3.60649	86	3.61130	31	3.61606
97	3.60173	42	3.60660	87	3.61140	32	3.61616
98	3.60184	43	3.60670	88	3.61151	33	3.61627
99	3.60195	44	3.60681	89	3.61162	34	3.61637
4000	3.60206	45	3.60692	90	3.61172	35	3.61648
4001	3.60217	46	3.60703	91	3.61183	36	3.61658
02	3.60228	47	3.60713	92	3.61194	37	3.61669
03	3.60239	48	3.60724	93	3.61204	38	3.61679
04	3.60249	49	3.60735	94	3.61215	39	3.61690
05	3.60260	50	3.60746	95	3.61225	40	3.61700

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
4141	3.61711	4186	3.62180	4231	3.62644	4276	3.63104
42	3.61721	87	3.62190	32	3.62655	77	3.63114
43	3.61731	88	3.62201	33	3.62665	78	3.63124
44	3.61742	89	3.62211	34	3.62675	79	3.63134
45	3.61752	90	3.62221	35	3.62685	80	3.63144
46	3.61763	91	3.62232	36	3.62696	81	3.63155
47	3.61773	92	3.62242	37	3.62706	82	3.63165
48	3.61784	93	3.62252	38	3.62716	83	3.63175
49	3.61794	94	3.62263	39	3.62726	84	3.63185
50	3.61805	95	3.62273	40	3.62737	85	3.63195
51	3.61815	96	3.62284	41	3.62747	86	3.63205
52	3.61826	97	3.62294	42	3.62757	87	3.63215
53	3.61836	98	3.62304	43	3.62767	88	3.63225
54	3.61847	99	3.62315	44	3.62778	89	3.63236
55	3.61857	4200	3.62325	45	3.62788	90	3.63246
56	3.61868	4201	3.62335	46	3.62798	91	3.63256
57	3.61878	02	3.62346	47	3.62808	92	3.63266
58	3.61888	03	3.62356	48	3.62818	93	3.63276
59	3.61899	04	3.62366	49	3.62829	94	3.63286
60	3.61909	05	3.62377	50	3.62839	95	3.63296
61	3.61920	06	3.62387	51	3.62849	96	3.63306
62	3.61930	07	3.62397	52	3.62859	97	3.63317
63	3.61941	08	3.62408	53	3.62870	98	3.63327
64	3.61951	09	3.62418	54	3.62880	99	3.63337
65	3.61962	10	3.62428	55	3.62890	4300	3.63347
66	3.61972	11	3.62439	56	3.62900	4301	3.63357
67	3.61982	12	3.62449	57	3.62910	02	3.63367
68	3.61993	13	3.62459	58	3.62921	03	3.63377
69	3.62003	14	3.62469	59	3.62931	04	3.63387
70	3.62014	15	3.62480	60	3.62941	05	3.63397
71	3.62024	16	3.62490	61	3.62951	06	3.63407
72	3.62034	17	3.62500	62	3.62961	07	3.63417
73	3.62045	18	3.62511	63	3.62972	08	3.63428
74	3.62055	19	3.62521	64	3.62982	09	3.63438
75	3.62066	20	3.62531	65	3.62992	10	3.63448
76	3.62076	21	3.62542	66	3.63002	11	3.63458
77	3.62086	22	3.62552	67	3.63012	12	3.63468
78	3.62097	23	3.62562	68	3.63022	13	3.63478
79	3.62107	24	3.62572	69	3.63033	14	3.63488
80	3.62118	25	3.62583	70	3.63043	15	3.63498
81	3.62128	26	3.62593	71	3.63053	16	3.63508
82	3.62138	27	3.62603	72	3.63063	17	3.63518
83	3.62149	28	3.62614	73	3.63073	18	3.63528
84	3.62159	29	3.62624	74	3.63083	19	3.63538
85	3.62170	30	3.62634	75	3.63094	20	3.63548

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
4321	3.63558	4366	3.64008	4411	3.64454	4456	3.64895
22	3.63568	67	3.64018	12	3.64464	57	3.64904
23	3.63579	68	3.64028	13	3.64473	58	3.64914
24	3.63589	69	3.64038	14	3.64483	59	3.64924
25	3.63599	70	3.64048	15	3.64493	60	3.64933
26	3.63609	71	3.64058	16	3.64503	61	3.64943
27	3.63619	72	3.64068	17	3.64513	62	3.64953
28	3.63629	73	3.64078	18	3.64523	63	3.64963
29	3.63639	74	3.64088	19	3.64532	64	3.64972
30	3.63649	75	3.64098	20	3.64542	65	3.64982
31	3.63659	76	3.64108	21	3.64552	66	3.64992
32	3.63669	77	3.64118	22	3.64562	67	3.65002
33	3.63679	78	3.64128	23	3.64572	68	3.65011
34	3.63689	79	3.64137	24	3.64582	69	3.65021
35	3.63699	80	3.64147	25	3.64591	70	3.65031
36	3.63709	81	3.64157	26	3.64601	71	3.65040
37	3.63719	82	3.64167	27	3.64611	72	3.65050
38	3.63729	83	3.64177	28	3.64621	73	3.65060
39	3.63739	84	3.64187	29	3.64631	74	3.65070
40	3.63749	85	3.64197	30	3.64640	75	3.65079
41	3.63759	86	3.64207	31	3.64650	76	3.65089
42	3.63769	87	3.64217	32	3.64660	77	3.65099
43	3.63779	88	3.64227	33	3.64670	78	3.65108
44	3.63789	89	3.64237	34	3.64680	79	3.65118
45	3.63799	90	3.64246	35	3.64689	80	3.65128
46	3.63809	91	3.64256	36	3.64699	81	3.65137
47	3.63819	92	3.64256	37	3.64709	82	3.65147
48	3.63829	93	3.64276	38	3.64719	83	3.65157
49	3.63839	94	3.64286	39	3.64729	84	3.65167
50	3.63849	95	3.64296	40	3.64738	85	3.65176
51	3.63859	96	3.64306	41	3.64748	86	3.65186
52	3.63869	97	3.64316	42	3.64758	87	3.65196
53	3.63879	98	3.64326	43	3.67768	88	3.65205
54	3.63889	99	3.64335	44	3.64777	89	3.65215
55	3.63899	4400	3.64345	45	3.64787	90	3.65225
56	3.63909	4401	3.64355	46	3.64797	91	3.65234
57	3.63919	02	3.64365	47	3.64807	92	3.65244
58	3.63929	03	3.64375	48	3.64816	93	3.65254
59	3.63939	04	3.64385	49	3.64826	94	3.65263
60	3.63949	05	3.64395	50	3.64836	95	3.65273
61	3.63959	06	3.64404	51	3.64846	96	3.65283
62	3.63969	07	3.64414	52	3.64856	97	3.65292
63	3.63979	08	3.64424	53	3.64865	98	3.65302
64	3.63988	09	3.64434	54	3.64875	99	3.65312
65	3.63998	10	3.64444	55	3.64885	4500	3.65321

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
4501	3.65331	4546	3.65763	4591	3.66191	4636	3.66614
02	3.65341	47	3.65773	92	3.66200	37	3.66624
03	3.65350	48	3.65782	93	3.66210	38	3.66633
04	3.65360	49	3.65792	94	3.66219	39	3.66642
05	3.65369	50	3.65801	95	3.66229	40	3.66652
06	3.65379	51	3.65811	96	3.66238	41	3.66661
07	3.65389	52	3.65820	97	3.66247	42	3.66671
08	3.65398	53	3.65830	98	3.66257	43	3.66680
09	3.65408	54	3.65839	99	3.66266	44	3.66689
10	3.65418	55	3.65849	4600	3.66276	45	3.66699
11	3.65427	56	3.65858	4601	3.66.85	46	3.66708
12	3.65437	57	3.65868	02	3.66295	47	3.66717
13	3.65447	58	3.65877	03	3.66304	48	3.66727
14	3.65456	59	3.65887	04	3.66314	49	3.66736
15	3.65466	60	3.65896	05	3.66323	50	3.66745
16	3.65475	61	3.65906	06	3.66332	51	3.66755
17	3.65485	62	3.65916	07	3.66342	52	3.66764
18	3.65495	63	3.65925	08	3.66351	53	3.66773
19	3.65504	64	3.65935	09	3.66361	54	3.66783
20	3.65514	65	3.65944	10	3.66370	55	3.66792
21	3.65523	66	3.65954	11	3.66380	56	3.66801
22	3.65533	67	3.65963	12	3.66389	57	3.66811
23	3.65543	68	3.65973	13	3.66398	58	3.66820
24	3.65552	69	3.65982	14	3.66408	59	3.66829
25	3.65562	70	3.65992	15	3.66417	60	3.66839
26	3.65571	71	3.66001	16	3.66427	61	3.66848
27	3.65581	72	3.66011	17	3.66436	62	3.66857
28	3.65591	73	3.66020	18	3.66445	63	3.66867
29	3.65600	74	3.66030	19	3.66455	64	3.66876
30	3.65610	75	3.66039	20	3.66464	65	3.66885
31	3.65619	76	3.66049	21	3.66474	66	3.66894
32	3.65629	77	3.66058	22	3.66483	67	3.66904
33	3.65635	78	3.66068	23	3.66492	68	3.66913
34	3.65648	79	3.66077	24	3.66502	69	3.66922
35	3.65658	80	3.66087	25	3.66511	70	3.66932
36	3.65667	81	3.66096	26	3.66521	71	3.66941
37	3.65677	82	3.66106	27	3.66530	72	3.66950
38	3.65686	83	3.66115	28	3.66539	73	3.66960
39	3.65696	84	3.66124	29	3.66549	74	3.66969
40	3.65706	85	3.66134	30	3.66558	75	3.66978
41	3.65715	86	3.66143	31	3.66567	76	3.66987
42	3.65725	87	3.66153	32	3.66577	77	3.66997
43	3.65734	88	3.66162	33	3.66586	78	3.67006
44	3.65744	89	3.66172	34	3.66596	79	3.67015
45	3.65753	90	3.66181	35	3.66605	80	3.67025

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
4681	3.67034	4726	3.67449	4771	3.67861	4816	3.68269
82	3.67043	27	3.67459	72	3.67870	17	3.68278
83	3.67052	28	3.67468	73	3.67879	18	3.68287
84	3.67062	29	3.67477	74	3.67888	19	3.68296
85	3.67071	30	3.67486	75	3.67897	20	3.68305
86	3.67080	31	3.67495	76	3.67906	21	3.68314
87	3.67090	32	3.67504	77	3.67916	22	3.68323
88	3.67099	33	3.67514	78	3.67925	23	3.68332
89	3.67108	34	3.67523	79	3.67934	24	3.68341
90	3.67117	35	3.67532	80	3.67943	25	3.68350
91	3.67127	36	3.67541	81	3.67952	26	3.68359
92	3.67136	37	3.67550	82	3.67961	27	3.68368
93	3.67145	38	3.67560	83	3.67970	28	3.68377
94	3.67154	39	3.67569	84	3.67979	29	3.68386
95	3.67164	40	3.67578	85	3.67988	30	3.68395
96	3.67173	41	3.67587	86	3.67997	31	3.68404
97	3.67182	42	3.67596	87	3.68006	32	3.68413
98	3.67191	43	3.67605	88	3.68015	33	3.68422
99	3.67201	44	3.67614	89	3.68024	34	3.68431
4700	3.67210	45	3.67624	90	3.68034	35	3.68440
4701	3.67219	46	3.67633	91	3.68043	36	3.68449
02	3.67228	47	3.67642	92	3.68052	37	3.68458
03	3.67238	48	3.67651	93	3.68061	38	3.68467
04	3.67247	49	3.67660	94	3.68070	39	3.68476
05	3.67256	50	3.67669	95	3.68079	40	3.68485
06	3.67265	51	3.67679	96	3.68088	41	3.68494
07	3.67274	52	3.67688	97	3.68097	42	3.68502
08	3.67284	53	3.67697	98	3.68106	43	3.68511
09	3.67293	54	3.67706	99	3.68115	44	3.68520
10	3.67302	55	3.67715	4800	3.68124	45	3.68529
11	3.67311	56	3.67724	4801	3.68133	46	3.68538
12	3.67321	57	3.67733	02	3.68142	47	3.68547
13	3.67330	58	3.67742	03	3.68151	48	3.68556
14	3.67339	59	3.67752	04	3.68160	49	3.68565
15	3.67348	60	3.67761	05	3.68169	50	3.68574
16	3.67357	61	3.67770	06	3.68178	51	3.68583
17	3.67367	62	3.67779	07	3.68187	52	3.68592
18	3.67376	63	3.67788	08	3.68196	53	3.68601
19	3.67385	64	3.67797	09	3.68205	54	3.68610
20	3.67394	65	3.67806	10	3.68215	55	3.68619
21	3.67403	66	3.67815	11	3.68224	56	3.68628
22	3.67413	67	3.67825	12	3.68233	57	3.68637
23	3.67422	68	3.67834	13	3.68242	58	3.68646
24	3.67431	69	3.67843	14	3.68251	59	3.68655
25	3.67440	70	3.67852	15	3.68260	60	3.68664

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
4861	3.68673	4906	3.69073	4951	3.69469	4996	3.69862
62	3.68681	07	3.69082	52	3.69478	97	3.69871
63	3.68690	08	3.69090	53	3.69487	98	3.69880
64	3.68699	09	3.69099	54	3.69496	99	3.69888
65	3.68708	10	3.69108	55	3.69504	5000	3.69897
66	3.68717	11	3.69117	56	3.69513	5001	3.69906
67	3.68726	12	3.69126	57	3.69522	02	3.69914
68	3.68735	13	3.69135	58	3.69531	03	3.69923
69	3.68744	14	3.69144	59	3.69539	04	3.69932
70	3.68753	15	3.69152	60	3.69548	05	3.69940
71	3.68762	16	3.69161	61	3.69557	06	3.69949
72	3.68771	17	3.69170	62	3.69566	07	3.69958
73	3.68780	18	3.69179	63	3.69574	08	3.69966
74	3.68789	19	3.69188	64	3.69583	09	3.69975
75	3.68797	20	3.69197	65	3.69592	10	3.69984
76	3.68806	21	3.69205	66	3.69601	11	3.69992
77	3.68815	22	3.69214	67	3.69609	12	3.70001
78	3.68824	23	3.69223	68	3.69618	13	3.70010
79	3.68833	24	3.69232	69	3.69627	14	3.70018
80	3.68842	25	3.69241	70	3.69626	15	3.70027
81	3.68851	26	3.69249	71	3.69644	16	3.70036
82	3.68860	27	3.69258	72	3.69653	17	3.70044
83	3.68869	28	3.69267	73	3.69662	18	3.70053
84	3.68878	29	3.69276	74	3.69671	19	3.70062
85	3.68886	30	3.69285	75	3.69679	20	3.70070
86	3.68895	31	3.69294	76	3.69688	21	3.70079
87	3.68904	32	3.69302	77	3.69697	22	3.70088
88	3.68913	33	3.69311	78	3.69705	23	3.70096
89	3.68922	34	3.69320	79	3.69714	24	3.70105
90	3.68931	35	3.69329	80	3.69723	25	3.70114
91	3.68940	36	3.69338	81	3.69732	26	3.70122
92	3.68949	37	3.69346	82	3.69740	27	3.70131
93	3.68958	38	3.69355	83	3.69749	28	3.70140
94	3.68966	39	3.69364	84	3.69758	29	3.70148
95	3.68975	40	3.69373	85	3.69767	30	3.70157
96	3.68984	41	3.69381	86	3.69775	31	3.70165
97	3.68993	42	3.69390	87	3.69784	32	3.70174
98	3.69002	43	3.69399	88	3.69793	33	3.70183
99	3.69011	44	3.69408	89	3.69801	34	3.70191
4900	3.69020	45	3.69417	90	3.69810	35	3.70200
4901	3.69028	46	3.69425	91	3.69819	36	3.70209
02	3.69037	47	3.69434	92	3.69827	37	3.70217
03	3.69046	48	3.69443	93	3.69836	38	3.70226
04	3.69055	49	3.69452	94	3.69845	39	3.70234
05	3.69064	50	3.69461	95	3.69854	40	3.70243

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
5041	3.70252	5086	3.70638	5131	3.71020	5176	3.71399
42	3.70260	87	3.70646	32	3.71028	77	3.71408
43	3.70269	88	3.70655	33	3.71037	78	3.71416
44	3.70278	89	3.70663	34	3.71046	79	3.71425
45	3.70286	90	3.70672	35	3.71054	80	3.71433
46	3.70295	91	3.70680	36	3.71063	81	3.71441
47	3.70303	92	3.70689	37	3.71071	82	3.71450
48	3.70312	93	3.70697	38	3.71079	83	3.71458
49	3.70321	94	3.70706	39	3.71088	84	3.71467
50	3.70329	95	3.70714	40	3.71096	85	3.71475
51	3.70338	96	3.70723	41	3.71105	86	3.71483
52	3.70346	97	3.70731	42	3.71113	87	3.71492
53	3.70355	98	3.70740	43	3.71122	88	3.71500
54	3.70364	99	3.70749	44	3.71130	89	3.71508
55	3.70372	5100	3.70757	45	3.71139	90	3.71517
56	3.70381	5101	3.70766	46	3.71147	91	3.71525
57	3.70389	02	3.70774	47	3.71155	92	3.71533
58	3.70398	03	3.70783	48	3.71164	93	3.71542
59	3.70406	04	3.70791	49	3.71172	94	3.71550
60	3.70415	05	3.70800	50	3.71181	95	3.71559
61	3.70424	06	3.70808	51	3.71189	96	3.71567
62	3.70432	07	3.70817	52	3.71198	97	3.71575
63	3.70441	08	3.70825	53	3.71206	98	3.71584
64	3.70449	09	3.70834	54	3.71214	99	3.71592
65	3.70458	10	3.70842	55	3.71223	5200	3.71600
66	3.70466	11	3.70851	56	3.71231	5201	3.71609
67	3.70475	12	3.70859	57	3.71240	02	3.71617
68	3.70484	13	3.70868	58	3.71248	03	3.71625
69	3.70492	14	3.70876	59	3.71257	04	3.71634
70	3.70501	15	3.70885	60	3.71265	05	3.71642
71	3.70509	16	3.70893	61	3.71273	06	3.71650
72	3.70518	17	3.70902	62	3.71282	07	3.71659
73	3.70526	18	3.70910	63	3.71290	08	3.71667
74	3.70535	19	3.70919	64	3.71299	09	3.71675
75	3.70544	20	3.70927	65	3.71307	10	3.71684
76	3.70552	21	3.70935	66	3.71315	11	3.71692
77	3.70561	22	3.70944	67	3.71324	12	3.71700
78	3.70569	23	3.70952	68	3.71332	13	3.71709
79	3.70578	24	3.70961	69	3.71341	14	3.71717
80	3.70586	25	3.70969	70	3.71349	15	3.71725
81	3.70595	26	3.70978	71	3.71357	16	3.71734
82	3.70603	27	3.70986	72	3.71366	17	3.71742
83	3.79612	28	3.70995	63	3.71374	18	3.71750
84	3.70621	29	3.71003	74	3.71383	19	3.71759
85	3.70629	30	3.71012	75	3.71391	20	3.71767

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
5221	3.71775	5266	3.72148	5311	3.72518	5356	3.72884
22	3.71784	67	3.72156	12	3.72526	57	3.72892
23	3.71792	68	3.72165	13	3.72534	58	3.72900
24	3.71800	69	3.72173	14	3.72542	59	3.72908
25	3.71809	70	3.72181	15	3.72550	60	3.72916
26	3.71817	71	3.72189	16	3.72559	61	3.72925
27	3.71825	72	3.72198	17	3.72567	62	3.72933
28	3.71834	73	3.72206	18	3.72575	63	3.72941
29	3.71842	74	3.72214	19	3.72583	64	3.72949
30	3.71850	75	3.72222	20	3.72591	65	3.72957
31	3.71858	76	3.72230	21	3.72599	66	3.72965
32	3.71867	77	3.72239	22	3.72607	67	3.72973
33	3.71875	78	3.72247	23	3.72616	68	3.72981
34	3.71883	79	3.72255	24	3.72624	69	3.72989
35	3.71892	80	3.72263	25	3.72632	70	3.72997
36	3.71900	81	3.72272	26	3.72640	71	3.73006
37	3.71908	82	3.72280	27	3.72648	72	3.73014
38	3.71917	83	3.72288	28	3.72656	73	3.73022
39	3.71925	84	3.72296	29	3.72665	74	3,73030
40	3.71933	85	3.72305	30	3.72673	75	3.73038
41	3.71941	86	3.72313	31	3.72681	76	3.73046
42	3.71950	87	3.72321	32	3.72689	77	3.73054
43	3.71958	88	3.72329	33	3.72697	78	3.73062
44	3.71966	89	3.72337	34	3.72705	79	3.73070
45	3.71975	90	3.72346	35	3.72713	80	3.73078
46	3.71983	91	3.72354	36	3.72722	81	3.73086
47	3.71991	92	3.72362	37	3.72730	82	3.73094
48	3.71999	93	3.72370	38	3.72738	83	3.73102
49	3.72008	94	3.72378	39	3.72746	84	3.73111
50	3.72016	95	3.72387	40	3.72754	85	3.73119
51	3.72024	96	3.72395	41	3.72762	86	3.73127
52	3.72032	97	3.72403	42	3.72770	87	3.73135
53	3.72041	98	3.72411	43	3.72779	88	3.73143
54	3.72049	99	3.72419	44	3.72787	89	3.73151
55	3.72057	5300	3.72428	45	3.72795	90	3.73159
56	3.72066	5301	3.72436	46	3.72803	91	3.73167
47	3.72074	02	3.72444	47	3.72811	92	3.73175
58	3.72082	03	3.72452	48	3.72819	93	3.73183
59	3.72090	04	3.72460	49	3.72827	94	3.73191
60	3.72099	05	3.72469	50	3.72835	95	3.73199
61	3.72107	06	3.72477	51	3.72843	96	3.73207
62	3.72115	07	3.72485	52	3.72852	97	3.73215
63	3.72123	08	3.72493	53	3.72860	98	3.73223
64	3.72132	09	3.72501	54	3.72868	99	3.73231
65	3.72140	10	3.72509	55	3.72876	5400	3.73239

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
5401	3.73247	5446	3.73608	5491	3.73965	5536	3.74320
02	3.73255	47	3.73616	92	3.73973	37	3.74327
03	3.73264	48	3.73624	93	3.73981	38	3.74335
04	3.73272	49	3.73632	94	3.73989	39	3.74343
05	3.73280	50	3.73640	95	3.73997	40	3.74351
06	3.73288	51	3.73648	96	3.74005	41	3.74359
07	3.73296	52	3.73656	97	3.74013	42	3.74367
08	3.73304	53	3.73664	98	3.74020	43	3.74374
09	3.73312	54	3.73672	99	3.74028	44	3.74382
10	3.73320	55	3.73679	5500	3.74036	45	3.74390
11	3.73328	56	3.73687	5501	3.74044	46	3.74398
12	3.73336	57	3.73695	02	3.74052	47	3.74406
13	3.73344	58	3.73703	03	3.74060	48	3.74414
14	3.73352	59	3.73711	04	3.74068	49	3.74421
15	3.73360	60	3.73719	05	3.74076	50	3.74429
16	3.73368	61	3.73727	06	3.74084	51	3.74437
17	3.73376	62	3.73735	07	3.74092	52	3.74445
18	3.73384	63	3.73743	08	3.74099	53	3.74453
19	3.73392	64	3.73751	09	3.74107	54	3.74461
20	3.73400	65	3.73759	10	3.74115	55	3.74468
21	3.73408	66	3.73767	11	3.74123	56	3.74476
22	3.73416	67	3.73775	12	3.74131	57	3.74484
23	3.73424	68	3.73783	13	3.74139	58	3.74492
24	3.73432	69	3.73791	14	3.74147	59	3.74500
25	3.73440	70	3.73799	15	3.74155	60	3.74507
26	3.73448	71	3.73807	16	3.74162	61	3.74515
27	3.73456	72	3.73815	17	3.74170	62	3.74523
28	3.73464	73	3.73823	18	3.74178	63	3.74531
29	3.73472	74	3.73830	19	3.74186	64	3.74539
30	3.73480	75	3.73828	20	3.74194	65	3.74547
31	3.73488	76	3.73846	21	3.74202	66	3.74554
32	3.73496	77	3.73854	22	3.74210	67	3.74562
33	3.73504	78	3.73862	23	3.74218	68	3.74570
34	3.73512	79	3.73870	24	3.74225	69	3.74578
35	3.73520	80	3.73878	25	3.74233	70	3.74586
36	3.73528	81	3.73886	26	3.74241	71	3.74593
37	3.73536	82	3.73894	27	3.74249	72	3.74601
38	3.73544	83	3.73902	28	3.74257	73	3.74609
39	3.73552	84	3.73909	29	3.74265	74	3.74617
40	3.73560	85	3.73918	30	3.74273	75	3.74624
41	3.73568	86	3.73926	31	3.74280	76	3.74632
42	3.73576	87	3.73934	32	3.74288	77	3.74640
43	3.73584	88	3.73941	33	3.74296	78	3.74648
44	3.73592	89	3.73949	34	3.74304	79	3.74656
45	3.73600	90	3.73957	35	3.74312	80	3.74663

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
5581	3.74671	5626	3.75020	5671	3.75366	5716	3.75709
82	3.74679	27	3.75028	72	3.75374	17	3.75717
83	3.74687	28	3.75035	73	3.75381	18	3.75724
84	3.74695	29	3.75043	74	3.75389	19	3.75732
85	3.74702	30	3.75051	75	3.75397	20	3.75740
86	3.74710	31	3.75059	76	3.75404	21	3.75747
87	3.74718	32	3.75066	77	3.75412	22	3.75755
88	3.74726	33	3.75074	78	3.75420	23	3.75762
89	3.74733	34	3.75082	79	3.75427	24	3.75770
90	3.74741	35	3.75089	80	3.75435	25	3.75778
91	3.74749	36	3.75097	81	3.75442	26	3.75785
92	3.74757	37	3.75105	82	3.75450	27	3.75793
93	3.74764	38	3.75113	83	3.75458	28	3.75800
94	3.74772	39	3.75120	84	3.75465	29	3.75808
95	3.74780	40	3.75128	85	3.75473	30	3.75815
96	3.74788	41	3.75136	86	3.75481	31	3.75823
97	3.74796	42	3.75143	87	3.75488	32	3.75831
98	3.74803	43	3.75151	88	3.75496	33	3.75838
99	3.74811	44	3.75159	89	3.75504	34	3.75846
5600	3.74819	45	3.75166	90	3.75511	35	3.75853
5601	3.74827	46	3.75174	91	3.75519	36	3.75861
02	3.74834	47	3.75182	92	3.75526	37	3.75868
03	3.74842	48	3.75189	93	3.75534	38	3.75876
04	3.74850	49	3.75197	94	3.75542	39	3.75884
05	3.74858	50	3.75205	95	2.75549	40	3.75891
06	3.74865	51	3.75213	96	3.75557	41	3.75899
07	3.74873	52	3.75220	97	3.75565	42	3.75906
08	3.74881	53	3.75228	98	3.75572	43	3.75914
09	3.74889	54	3.75236	99	3.75580	44	3.75921
10	3.74896	55	3.75243	5700	3.75587	45	3.75929
11	3.74904	56	3.75251	5701	3.75595	46	3.75937
12	3.74912	57	3.75259	02	3.75603	47	3.75944
13	3.74920	58	3.75266	03	3.75610	48	3.75952
14	3.74927	59	3.75274	04	3.75618	49	3.75959
15	3.74935	60	3.75282	05	3.75626	50	3.75967
16	3.74943	61	3.75289	06	3.75633	51	3.75974
17	3.74950	62	3.75297	07	3.75641	52	3.75982
18	3.74958	63	3.75305	08	3.75648	53	3.75989
19	3.74966	64	3.75312	09	3.75616	54	3.75997
20	3.74974	65	3.75320	10	3.75664	55	3.76005
21	3.74931	66	3.75328	11	3.75671	56	3.76012
22	3.74989	67	3.75335	12	3.75679	57	3.76020
23	3.74997	68	3.75343	13	3.75686	58	3.76027
24	3.75005	69	3.75351	14	3.75694	59	3.76035
25	3.75012	70	3.75358	15	3.75702	60	3.76042

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
5761	3.76050	5806	3.76388	5851	3.76723	5896	3.77056
62	3.76057	07	3.76395	52	3.76730	97	3.77063
63	3.76065	08	3.76403	53	3.76738	98	3.77070
64	3.76072	09	3.76410	54	3.76745	99	3.77078
65	3.76080	10	3.76418	55	3.76753	5900	3.77085
66	3.76087	11	3.76425	56	3.76760	5901	3.77093
67	3.76095	12	3.76433	57	3.76768	02	3.77100
68	3.76103	13	3.76440	58	3.76775	03	3.77107
69	3.76110	14	3.76448	59	3.76782	04	3.77115
70	3.76118	15	3.76455	60	3.76790	05	3.77122
71	3.76125	16	3.76462	61	3.76797	06	3.77129
72	3.76133	17	3.76470	62	3.76805	07	3.77137
73	3.76140	18	3.76477	63	3.76812	08	3.77144
74	3.76148	19	3.76485	64	3.76819	09	3.77151
75	3.76155	20	3.76492	65	3.76827	10	3.77159
76	3.76163	21	3.76500	66	3.76834	11	3.77166
77	3.76170	22	3.76507	67	3.76842	12	3.77173
78	3.76178	23	3.76515	68	3.76849	13	3.77181
79	3.76185	24	3.76522	69	3.76856	14	3.77188
80	3.76193	25	3.76530	70	3.76864	15	3.77195
81	3.76200	26	3.76537	71	3.76871	16	3.77203
82	3.76208	27	3.76545	72	3.76879	17	3.77210
83	3.76215	28	3.76552	73	3.76886	18	3.77218
84	3.76223	29	3.76559	74	3.76893	19	3.77225
85	3.76230	30	3.76567	75	3.76901	20	3.77232
86	3.76238	31	3.76574	76	3.76908	21	3.77240
87	3.76245	32	3.76582	77	3.76916	22	3.77247
88	3.76253	33	3.76589	78	3.76923	23	3.77254
89	3.76260	34	3.76597	79	3.76930	24	3.77262
90	3.76268	35	3.76604	80	3.76938	25	3.77269
91	3.76275	36	3.76612	81	3.76945	26	3.77276
92	3.76283	37	3.76619	82	3.76953	27	3.77283
93	3.76290	38	3.76626	83	3.76960	28	3.77291
94	3.76298	39	3.76634	84	3.76967	29	3.77298
95	3.76305	40	3.76641	85	3.76975	30	3.77305
96	3.76313	41	3.76649	86	3.76982	31	3.77313
97	3.76320	42	3.76656	87	3.76989	32	3.77320
98	3.76328	43	3.76664	88	3.76997	33	3.77327
99	3.76335	44	3.76671	89	3.77004	34	3.77335
5800	3.76343	45	3.76678	90	3.77012	35	3.77342
5801	3.76350	46	3.76686	91	3.77019	36	3.77349
02	3.76358	47	3.76693	92	3.77026	37	3.77357
03	3.76365	48	3.76701	93	3.77034	38	3.77364
04	3.76373	49	3.76708	94	3.77041	39	3.77371
05	3.76380	50	3.76716	95	3.77048	40	3.77379

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
5941	3.77386	5986	3.77714	6031	3.78039	6076	3.78362
42	3.77393	87	3.77721	32	3.78046	77	3.78369
43	3.77401	88	3.77728	33	3.78053	78	3.78376
44	3.77408	89	3.77735	34	3.78061	79	3.78383
45	3.77415	90	3.77743	35	3.78068	80	3.78390
46	3.77422	91	3.77750	36	3.78075	81	3.78398
47	3.77430	92	3.77757	37	3.78082	82	3.78405
48	3.77437	93	3.77764	38	3.78089	83	3.78412
49	3.77444	94	3.77772	39	3.78097	84	3.78419
50	3.77452	95	3.77779	40	3.78104	85	3.78426
51	3.77459	96	3.77786	41	3.78111	86	3.78433
52	3.77466	97	3.77793	42	3.78118	87	3.78440
53	3.77474	98	3.77801	43	3.78125	88	3.78447
54	3.77481	99	3.77808	44	3.78132	89	3.78455
55	3.77488	6000	3.77815	45	3.78140	90	3.78462
56	3.77495	6001	3.77822	46	3.78147	91	3.78469
57	3.77503	02	3.77830	47	3.78154	92	3.78476
58	3.77510	03	3.77837	48	3.78161	93	3.78483
59	3.77517	04	3.77844	49	3.78168	94	3.78490
60	3.77525	05	3.77851	50	3.78176	95	3.78497
61	3.77532	06	3.77859	51	3.78183	96	3.78505
62	3.77539	07	3.77866	52	3.78190	97	3.78512
63	3.77546	08	3.77873	53	3.78197	98	3.78519
64	3.77554	09	3.77880	54	3.78204	99	3.78526
65	3.77561	10	3.77887	55	3.78211	6100	3.78533
66	3.77568	11	3.77895	56	3.78219	6101	3.78540
67	3.77576	12	3.77902	57	3.78226	02	3.78547
68	3.77583	13	3.77909	58	3.78233	03	3.78554
69	3.77590	14	3.77916	59	3.78240	04	3.78561
70	3.77597	15	3.77924	60	3.78247	05	3.78569
71	3.77605	16	3.77931	61	3.78254	06	3.78576
72	3.77612	17	3.77938	62	3.78262	07	3.78583
73	3.77619	18	3.77945	63	3.78269	08	3.78590
74	3.77627	19	3.77952	64	3.78276	09	3.78597
75	3.77634	20	3.77960	65	3.78283	10	3.78604
76	3.77641	21	3.77967	66	3.78290	11	3.78611
77	3.77648	22	3.77974	67	3.78297	12	3.78618
78	3.77656	23	3.77981	68	3.78305	13	3.78625
79	3.77663	24	3.77989	69	3.78312	14	3.78633
80	3.77670	25	3.77996	70	3.78319	15	3.78640
81	3.77677	26	3.78003	71	3.78326	16	3.78647
82	3.77685	27	3.78010	72	3.78333	17	3.78654
83	3.77692	28	3.78017	73	3.78340	18	3.78661
84	3.77699	29	3.78025	74	3.78347	19	3.78668
85	3.77706	30	3.78032	75	3.78355	20	3.78675

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
6121	3.78682	6166	3.79000	6211	3.79316	6256	3.79630
22	3.78689	67	3.79007	12	3.79323	57	3.79637
23	3.78696	68	3.79014	13	3.79330	58	3.79644
24	3.78704	69	3.79021	14	3.79337	59	3.79650
25	3.78711	70	3.79029	15	3.79344	60	3.79657
26	3.78718	71	3.79036	16	3.79351	61	3.79664
27	3.78725	72	3.79043	17	3.79358	62	3.79671
28	3.78732	73	3.79050	18	3.79365	63	3.79678
29	3.78739	74	3.79057	19	3.79372	64	3.79685
30	3.78746	75	3.79064	20	3.79379	65	3.79692
31	3.78753	76	3.79071	21	3.79386	66	3.79699
32	3.78760	77	3.79078	22	3.79393	67	3.79706
33	3.78767	78	3.79085	23	3.79400	68	3.79713
34	3.78774	79	3.79092	24	3.79407	69	3.79720
35	3.78781	80	3.79099	25	3.79414	70	3.79727
36	3.78789	81	3.79106	26	3.79421	71	3.79734
37	3.78796	82	3.79113	27	3.79428	72	3.79741
38	3.78803	83	3.79120	28	3.79435	73	3.79748
39	3.78810	84	3.79127	29	3.79442	74	3.79754
40	3.78817	85	3.79134	30	3.79449	75	3.79761
41	3.78824	86	3.79141	31	3.79456	76	3.79768
42	3.78831	87	3.79148	32	3.79463	77	3.79775
43	3.78838	88	3.79155	33	3.79470	78	3.79782
44	3.78845	89	3.79162	34	3.79477	79	3.79789
45	3.78852	90	3.79169	35	3.79484	80	3.79796
46	3.78859	91	3.79176	36	3.79491	81	3.79803
47	3.78866	92	3.79183	37	3.79498	82	3.79810
48	3.78873	93	3.79190	38	3.79505	83	3.79817
49	3.78880	94	3.79197	39	3.79512	84	3.79824
50	3.78888	95	3.79204	40	3.79518	85	3.79831
51	3.78895	96	3.79211	41	3.79525	86	3.79837
52	3.78902	97	3.79218	42	3.79532	87	3.79844
53	3.78909	98	3.79225	43	3.79539	88	3.79851
54	3.78916	99	3.79232	44	3.79546	89	3.79858
55	3.78923	6200	3.79239	45	3.79553	90	3.79865
56	3.78930	6201	3.79246	46	3.79560	91	3.79872
57	3.78937	02	3.79253	47	3.79567	92	3.79879
58	3.78944	03	3.79260	48	3.79574	93	3.79886
59	3.78951	04	3.79267	49	3.79581	94	3.79893
60	3.78958	05	3.79274	50	3.79588	95	3.79900
61	3.78965	06	3.79281	51	3.79595	96	3.79906
62	3.78972	07	3.79288	52	3.79602	97	3.79913
63	3.78979	08	3.79295	53	3.79609	98	3.79920
64	3.78986	09	3.79302	54	3.79616	99	3.79927
65	3.78993	10	3.79309	55	3.79623	6300	3.79934

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
6301	3.79941	6346	3.80250	6391	3.80557	6436	3.80862
02	3.79948	47	3.80257	92	3.80564	37	3.80868
03	3.79955	48	3.80264	93	3.80570	38	3.80875
04	3.79962	49	3.80271	94	3.80577	39	3.80882
05	3.79969	50	3.80277	95	3.80584	40	3.80889
06	3.79975	51	3.80284	96	3.80591	41	3.80895
07	3.79982	52	3.80291	97	3.80598	42	3.80902
08	3.79989	53	3.80298	98	3.80604	43	3.80909
09	3.79996	54	3.80305	99	3.80611	44	3.80916
10	3.80003	55	3.80212	6400	3.80618	45	3.80922
11	3.80010	56	3.80318	6401	3.80625	46	3.80929
12	3.80017	57	3.80325	02	3.80632	47	3.80936
13	3.80024	58	3.80332	03	3.80638	48	3.80943
14	3.80030	59	3.80339	04	3.80645	49	3.80949
15	3.80037	60	3.80346	05	3.80652	50	3.80956
16	3.80044	61	3.80353	06	3.80659	51	3.80963
17	3.80051	62	3.80359	07	3.80665	52	3.80969
18	3.80058	63	3.80366	08	3.80672	53	3.80976
19	3.80065	64	3.80373	09	3.80679	54	3.80983
20	3.80072	65	3.80380	10	3.80686	55	3.80990
21	3.80079	66	3.80387	11	3.80693	56	3.80996
22	3.80085	67	3.80393	12	3.80699	57	3.81003
23	3.80092	68	3.80400	13	3.80706	58	3.81010
24	3.80099	69	3.80407	14	3.80713	59	3.81017
25	3.80106	70	3.80414	15	3.80720	60	3.81023
26	3.80113	71	3.80421	16	3.80726	61	3.81030
27	3.80120	72	3.80428	17	3.80733	62	3.81037
28	3.80127	73	3.80434	18	3.80740	63	3.81043
29	3.80134	74	3.80441	19	3.80747	64	3.81050
30	3.80140	75	3.80448	20	3.80754	65	3.81057
31	3.80147	76	3.80455	21	3.80760	66	3.81064
32	3.80154	77	3.80462	22	3.80767	67	3.81070
33	3.80161	78	3.80468	23	3.80774	68	3.81077
34	3.80168	79	3.80475	24	3.80781	69	3.81084
35	3.80175	80	3.80482	25	3.80787	70	3.81090
36	3.80182	81	3.80489	26	3.80794	71	3.81097
37	3.80188	82	3.80496	27	3.80801	72	3.81104
38	3.80195	83	3.80502	28	3.80808	73	3.81111
39	3.80202	84	3.80509	29	3.80814	74	3.81117
40	3.80209	85	3.80516	30	3.80821	75	3.81124
41	3.80216	86	3.80523	31	3.80828	76	3.81131
42	3.80223	87	3.80530	32	3.80835	77	3.81137
43	3.80229	88	3.80536	33	3.80841	78	3.81144
44	3.80236	89	3.80543	34	3.80848	79	3.81151
45	3.80243	90	3.80550	35	3.80855	80	3.81158

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar,
6481	3.81164	6526	3.81465	6571	3.81763	6616	3.82060
82	3.81171	27	3.81471	72	3.81770	17	3.82066
83	3.81178	28	3.81478	73	3.81776	18	3.82073
84	3.81184	29	3.81485	74	3.81783	19	3.82079
85	3.81191	30	3.81491	75	3.81790	20	3.82086
86	3.81198	31	3.81498	76	3.81796	21	3.82092
87	3.81204	32	3.81505	77	3.81803	22	3.82099
88	3.81211	33	3.81511	78	3.81809	23	3.82105
89	3.81218	34	3.81518	79	3.81816	24	3.82112
90	3.81224	35	3.81525	80	3.81823	25	3.82119
91	3.81231	36	3.81531	81	3.81829	26	3.82125
92	3.81238	37	3.81538	82	3.81836	27	3.82132
93	3.81245	38	3.81544	83	3.81842	28	3.82138
94	3.81251	39	3.81551	84	3.81849	29	3.82145
95	3.81258	40	3.81558	85	3.81856	30	3.82151
96	3.81265	41	3.81564	86	3.81862	31	3.82158
97	3.81271	42	3.81571	87	3.81869	32	3.82164
98	3.81278	43	3.81578	88	3.81875	33	3.82171
99	3.81285	44	3.81584	89	3,81882	34	3.82178
6500	3.81291	45	3.81591	90	3.81889	35	3.82184
6501	3.81298	46	3.81598	91	3.81895	36	3.82191
02	3.81305	47	3.81604	92	3.81902	37	3.82197
03	3.81311	48	3.81611	93	3.81908	38	3.82204
04	3.81318	49	3.81618	94	3.81915	39	3.82210
05	3.81325	50	3.81624	95	3.81921	40	3.82217
06	3.81331	51	3.81631	96	3.81928	41	3.82223
07	3.81338	52	3.81637	97	3.81935	42	3.82230
08	3.81345	53	3.81644	98	3.81941	43	3.82236
09	3.81351	54	3.81651	99	3.81948	44	3.82243
10	3.81358	55	3.81657	6600	3.81954	45	3.82250
11	3.81365	56	3.81664	6601	3.81961	46	3.82256
12	3.81371	57	3.81671	02	3.81968	47	3.82263
13	3.81378	58	3.81677	03	3.81974	48	3.82269
14	3.81385	59	3.81684	04	3.81981	49	3.82276
15	3.81391	60	3.81690	05	3.81987	50	3.82282
16	3.81398	61	3.81697	06	3.81994	51	3.82289
17	3.81405	62	3.81704	07	3.82000	52	3.82295
18	3.81411	63	3.81710	08	3.82007	53	3.82302
19	3.81418	64	3.81717	09	3.82014	54	3.82308
20	3.81425	65	3.81723	10	3.82020	55	3.82315
21	3.81431	66	3.81730	11	3.82027	56	3.82321
22	3.81438	67	3.81737	12	3.82033	57	3.82328
23	3.81445	68	3.81743	13	3.82040	58	3.82334
24	3.81451	69	3.81750	14	3.82046	59	3.82341
25	3.81458	70	3.81757	15	3.82053	60	3.82347

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
6661	3.82354	6706	3.82646	6751	3.82937	6796	3.83225
62	3.82360	07	3.82653	52	3.82943	97	3.83232
63	3.82367	08	3.82659	53	3.82950	98	3.83238
64	3.82374	09	3.82666	54	3.82956	99	3.83245
65	3.82380	10	3.82672	55	3.82963	6800	3.83251
66	3.82387	11	3.82679	56	3.82969	6801	3.83257
67	3.82393	12	3.82685	57	3.82975	02	3.83264
68	3.82400	13	3.82692	58	3.82982	03	3.83270
69	3.82406	14	3.82698	59	3.82988	04	3.83276
70	3.82413	15	3.82705	60	3.82995	05	3.83283
71	3.82419	16	3.82711	61	3.83001	06	3.83289
72	3.82426	17	3.82718	62	3.83008	07	3.83296
73	3.82432	18	3.82724	63	3.83014	08	3.83302
74	3.82439	19	3.82730	64	3.83020	09	3.83308
75	3.82445	20	3.82737	65	3.83027	10	3.83315
76	3.82452	21	3.82743	66	3.83033	11	3.83321
77	3.82458	22	3.82750	67	3.83040	12	3.83327
78	3.82465	23	3.82756	68	3.83046	13	3.83334
79	3.82471	24	3.82763	69	3.83052	14	3.83340
80	3.82478	25	3.82769	70	3.83059	15	3.83347
81	3.82484	26	3.82776	71	3.83065	16	3.83353
82	3.82491	27	3.82782	72	3.83072	17	3.83359
83	3.82497	28	3.82789	73	3.83078	18	3.83366
84	3.82504	29	3.82795	74	3.83085	19	3.83372
85	3.82510	30	3.82802	75	3.83091	20	3.83378
86	3.82517	31	3.82808	76	3.83097	21	3.83385
87	3.82523	32	3.82814	77	3.83104	22	3.83391
88	3.82530	33	3.82821	78	3.83110	23	3.83398
89	3.82536	34	3.82827	79	3.83117	24	3.83404
90	3.82543	35	3.82834	80	3.83123	25	3.83410
91	3.82549	36	3.82840	81	3.83129	26	3.83417
92	3.82556	37	3.82847	82	3.83136	27	3.83423
93	3.82562	38	3.82853	83	3.83142	28	3.83429
94	3.82569	39	3.82860	84	3.83149	29	3.83436
95	3.82575	40	3.82866	85	3.83155	30	3.83442
96	3.82582	41	3.82872	86	3.83161	31	3.83448
97	3.82588	42	3.82879	87	3.83168	32	3.83455
98	3.82595	43	3.82885	88	3.83174	33	3.83461
99	3.82601	44	3.82892	89	3.83181	34	3.83468
6700	3.82607	45	3.82898	90	3.83187	35	3.83474
6701	3.82614	46	3.82905	91	3.83193	36	3.83480
02	3.82620	47	3.82911	92	3.83200	37	3.83487
03	3.82627	48	3.82918	93	3.83206	38	3.83493
04	3.82633	49	3.82924	94	3.83213	39	3.83499
05	3.82640	50	3.82930	95	3.83219	40	3.83506

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
6841	3.83512	6886	3.83797	6931	3.84080	6976	3.84361
42	3.83518	87	3.83803	32	3.84086	77	3.84367
43	3.83525	88	3.83809	33	3.84092	78	3.84373
44	3.83531	89	3.83816	34	3.84098	79	3.84379
45	3.83537	90	3.83822	35	3.84105	80	3.84386
46	3.83544	91	3.83828	36	3.84111	81	3.84392
47	3.83550	92	3.83835	37	3.84117	82	3.84398
48	3.83556	93	3.83841	38	3.84123	83	3.84404
49	3.83563	94	3.83847	39	3.84130	84	3.84410
50	3.83569	95	3.83853	40	3.84136	85	3.84417
51	3.83575	96	3.83860	41	3.84142	86	3.84423
52	3.83582	97	3.83866	42	3.84148	87	3.84429
53	3.83588	98	3.83872	43	3.84155	88	3.84435
54	3.83594	99	3.83879	44	3.84161	89	3.84442
55	3.83601	6900	3.83885	45	3.84167	90	3.84448
56	3.83607	6901	3.83891	46	3.84173	91	3.84454
57	3.83613	02	3.83898	47	3.84180	92	3.84460
58	3.83620	03	3.83904	48	3.84186	93	3.84466
59	3.83626	04	3.83910	49	3.84192	94	3.84473
60	3.83632	05	3.83916	50	3.84198	95	3.84479
61	3.83639	06	3.83923	51	3.84205	96	.384485
62	3.83645	07	3.83929	52	3.84211	97	3.84491
63	3.83651	08	3.83935	53	3.84217	98	3.84497
64	3.83658	09	3.83942	54	3.84223	99	3.84504
65	3.83664	10	3.83948	55	3.84230	7000	3.84510
66	3.83670	11	3.83954	56	3.84236	7001	3.84516
67	3.83677	12	3.83960	57	3.84242	02	3.84522
68	3.83683	13	3.83967	58	3.84248	03	3.84528
69	3.83689	14	3.83973	59	3.84255	04	3.84535
70	3.83696	15	3.83979	60	3.84261	05	3.84541
71	3.83702	16	3.83986	61	3.84267	06	3.84547
72	3.83708	17	3.83992	62	3.84273	07	3.84553
73	3.83715	18	3.83998	63	3.84280	08	3.84559
74	3.83721	19	3.84004	64	3.84286	09	3.84566
75	3.83727	20	3.84011	65	3.84292	10	3.84572
76	3.83734	21	3.84017	66	3.84298	11	3.84578
77	3.83740	22	3.84023	67	3.84305	12	3.84584
78	3.83746	23	3.84029	68	3.84311	13	3.84590
79	3.83753	24	3.84036	69	3.84317	14	.384597
80	3.83759	25	3.84042	70	3.84323	15	3.84603
81	3.83765	26	3.84048	71	3.84330	16	3.84609
82	3.83771	27	3.84055	72	3.84336	17	3.84615
83	3.83778	28	3.84061	73	3.84342	18	3.84621
84	3.83784	29	3.84067	74	3.84348	19	3.84628
85	3.83790	30	3.84073	75	3.84354	20	3.84634

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
7021	3.84640	7066	3.84917	7111	3.85193	7156	3.85467
22	3.84646	67	3.84924	12	3.85199	57	3.85473
23	3.84652	68	3.84930	13	3.85205	58	3.85479
24	3.84658	69	3.84936	14	3.85211	59	3.85485
25	3.84665	70	3.84942	15	3.85217	60	3.85491
26	3.84671	71	3.84948	16	3.85224	61	3.85497
27	3.84677	72	3.84954	17	3.85230	62	3.85503
28	3.84683	73	3.84960	18	3.85236	63	3.85510
29	3.84689	74	3.84967	19	3.85242	64	3.85516
30	3.84696	75	3.84973	20	3.85248	65	3.85522
31	3.84702	76	3.84979	21	3.85254	66	3.85528
32	3.84708	77	3.84985	22	3.85260	67	3.85534
33	3.84714	78	3.84991	23	3.85266	68	3.85540
34	3.84720	79	3.84997	24	3.85272	69	3.85546
35	3.84726	80	3.85003	25	3.85278	70	3.85552
36	3.84733	81	3.85009	26	3.85285	71	3.85558
37	3.84739	82	3.85016	27	3.85291	72	3.85564
38	3.84745	83	3.85022	28	3.85297	73	3.85570
39	3.84751	84	3.85028	29	3.85303	74	3.85576
40	3.84757	85	3.85034	30	3.85309	75	3.85582
41	3.84763	86	3.85040	31	3.85315	76	3.85588
42	3.84770	87	3.85046	32	3.85321	77	3.85594
43	3.84776	88	3.85052	33	3.85327	78	3.85600
44	3.84782	89	3.85058	34	3.85333	79	3.85606
45	3.84788	90	3.85065	35	3.85339	80	3.85612
46	3.84794	91	3.85071	36	3.85345	81	3.85618
47	3.84800	92	3.85077	37	3.85352	82	3.85625
48	3.84807	93	3.85083	38	3.85358	83	3.85631
49	3.84813	94	3.85089	39	3.85364	84	3.85637
50	3.84819	95	3.85095	40	3.85370	85	3.85643
51	3.84825	96	3.85101	41	3.85376	86	3.85649
52	3.84831	97	3.85107	42	3.85382	87	3.85655
53	3.84837	98	3.85114	43	3.85388	88	3.85661
54	3.84844	99	3.85120	44	3.85394	89	3.85667
55	3.84850	7100	3.85126	45	3.85400	90	3.85673
56	3.84856	7101	3.85132	46	3.85406	91	3.85679
47	3.84862	02	3.85138	47	3.85412	92	3.85685
58	3.84868	03	3.85144	48	3.85418	93	3.85691
59	3.84874	04	3.85150	49	3.85425	94	3.85697
60	3.84880	05	3.85156	50	3.85431	95	3.85703
61	3.84887	06	3.85163	51	3.85437	96	3.85709
62	3.84893	07	3.85169	52	3.85443	97	3.85715
63	3.84899	08	3.85175	53	3.85449	98	3.85721
64	3.84905	09	3.85181	54	3.85455	99	3.85727
65	3.84911	10	3.85187	55	3.85461	7200	3.85733

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
7201	3.85739	7246	3.86010	7291	3.86279	7336	3.86546
02	3.85745	47	3.86016	92	3.86285	37	3.86552
03	3.85751	48	3.86022	93	3.86291	38	3.86558
04	3.85757	49	3.86028	94	3.86297	39	3.86564
05	3.85763	50	3.86034	95	3.86303	40	3.86570
06	3.85769	51	3.86040	96	3.86308	41	3.86576
07	3.85775	52	3.86046	97	3.86314	42	3.86581
08	3.85781	53	3.86052	98	3.86320	43	3.86587
09	3.85788	54	3.86058	99	3.86326	44	3.86593
10	3.85794	55	3.86064	7300	3.86332	45	3.86599
11	3.85800	56	3.86070	7301	3.86338	46	3.86605
12	3.85806	57	3.86076	02	3.86344	47	3.86611
13	3.85812	58	3.86082	03	3.86350	48	3.86617
14	3.85818	59	3.86088	04	3.86356	49	3.86623
15	3.85824	60	3.86094	05	3.86362	50	3.86629
16	3.85830	61	3.86100	06	3.86368	51	3.86635
17	3.85836	62	3.86106	07	3.86374	52	3.86641
18	3.85842	63	3.86112	08	3.86380	53	3.86646
19	3.85848	64	3.86118	09	3.86386	54	3.86652
20	3.85854	65	3.86124	10	3.86392	55	3.86658
21	3.85860	66	3.86130	11	3.86398	56	3.86664
22	3.85866	67	3.86136	12	3.86404	57	3.86670
23	3.85872	68	3.86141	13	3.86410	58	3.86676
24	3.85878	69	3.86147	14	3.86416	59	3.86682
25	3.85884	70	3.86153	15	3.86421	60	3.86688
26	3.85890	71	3.86159	16	3.86427	61	3.86694
27	3.85896	72	3.86165	17	3.86433	62	3.86700
28	3.85902	73	3.86171	18	3.86439	63	3.86705
29	3.85908	74	3.86177	19	3.86445	64	3.86711
30	3.85914	75	3.86183	20	3.86451	65	3.86717
31	3.85920	76	3.86189	21	3.86457	66	3.86723
32	3.85926	77	3.86195	22	3.86463	67	3.86729
33	3.85932	78	3.86201	23	3.86469	68	3.86735
34	3.85938	79	3.86207	24	3.86475	69	3.86741
35	3.85944	80	3.86213	25	3.86481	70	3.86747
36	3.85950	81	3.86219	26	3.86487	71	3.86753
37	3.85956	82	3.86225	27	3.86493	72	3.86759
38	3.85962	83	3.86231	28	3.86499	73	3.86764
39	3.85968	84	3.86237	29	3.86504	74	3.86770
40	3.85974	85	3.86243	30	3.86510	75	3.86776
41	3.85980	86	3.86249	31	3.86516	76	3.86782
42	3.85986	87	3.86255	32	3.86522	77	3.86788
43	3.85992	88	3.86261	33	3.86528	78	3.86794
44	3.85998	89	3.86267	34	3.86534	79	3.86800
45	3.86004	90	3.86273	35	3.86540	80	3.86806

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
7381	3.86812	7426	3.87075	7471	3.87338	7516	3.87599
82	3.86817	27	3.87081	72	3.87344	17	3.87604
83	3.86823	28	3.87087	73	3.87350	18	3.87610
84	3.86829	29	3.87093	74	3.87355	19	3.87616
85	3.86835	30	3.87099	75	3.87361	20	3.87622
86	3.86841	31	3.87105	76	3.87367	21	3.87628
87	3.86847	32	3.87111	77	3.87373	22	3.87633
88	3.86853	33	3.87116	78	3.87379	23	3.87639
89	3.86859	34	3.87122	79	3.87384	24	3.87645
90	3.86864	35	3.87128	80	3.87390	25	3.87651
91	3.86870	36	3.87134	81	3.87396	26	3.87656
92	3.86876	37	3.87140	82	3.87402	27	3.87662
93	3.86882	38	3.87146	83	3.87408	28	3.87668
94	3.86888	39	3.87151	84	3.87413	29	3.87674
95	3.86894	40	3.87157	85	3.87419	20	3.87680
96	3.86900	41	3.87163	86	3.87425	31	3.87685
97	3.86906	42	3.87169	87	3.87431	32	3.87691
98	3.86911	43	3.87175	88	3.87437	33	3.87697
99	3.86917	44	3.87181	89	3.87442	34	3.87703
7400	3.86923	45	3.87186	90	3.87448	35	3.87708
7401	3.86929	46	3.87192	91	3.87454	36	3.87714
02	3.86935	47	3.87198	92	3.87460	37	3.87720
03	3.86941	48	3.87204	93	3.87466	38	3.87726
04	3.86947	49	3.87210	94	3.87471	39	3.87731
05	3.86953	50	3.87216	95	3.87477	40	3.87737
06	3.86958	51	3.87221	96	3.87483	41	3.87743
07	3.86964	52	3.87227	97	3.87489	42	3.87749
08	3.86970	53	3.87233	98	3.87495	43	3.87754
09	3.86976	54	3.87239	99	3.87500	44	3.87760
10	3.86982	55	3.87245	7500	3.87506	45	3.87766
11	3.86988	56	3.87251	7501	3.87512	46	3.87772
12	3.86994	57	3.87256	02	3.87518	47	3.87777
13	3.86999	58	3.87262	03	3.87523	48	3.87783
14	3.87005	59	3.87268	04	3.87529	49	3.87789
15	3.87011	60	3.87274	05	3.87535	50	3.87795
16	3.87017	61	3.87280	06	3.87541	51	3.87800
17	3.87023	62	3.87286	07	3.87547	52	3.87806
18	3.87029	63	3.87291	08	3.87552	53	3.87812
19	3.87035	64	3.87297	09	3.87558	54	3.87818
20	3.87040	65	3.87303	10	3.87564	55	3.87823
21	3.87046	66	3.87309	11	3.87570	56	3.87829
22	3.87052	67	3.87315	12	3.87576	57	3.87835
23	3.87058	68	3.87320	13	3.87581	58	3.87841
24	3.87064	69	3.87326	14	3.87587	59	3.87846
25	3.87070	70	3.87332	15	3.87593	60	3.87852

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
7561	3.87858	7606	3.88116	7651	3.88372	7696	3.88627
62	3.87864	07	3.88121	52	3.88378	97	3.88632
63	3.87869	08	3.88127	53	3.88383	98	3.88638
64	3.87875	09	3.88133	54	3.88389	99	3.88643
65	3.87881	10	3.88138	55	3.88395	7700	3.88649
66	3.87887	11	3.88144	56	3.88400	7701	3.88655
67	3.87892	12	3.88150	57	3.88406	02	3.88660
68	3.87898	13	3.88156	58	3.88412	03	3.88666
69	3.87904	14	3.88161	59	3.88417	04	3.88672
70	3.87900	15	3.88167	60	3.88423	05	3.88677
71	3.87915	16	3.88173	61	3.88429	06	3.88683
72	3.87921	17	3.88178	62	3.88434	07	3.88689
73	3.87927	18	3.88184	63	3.88440	08	3.88694
74	3.37933	19	3.88190	64	3.88446	09	3.88700
75	3.87938	20	3.88196	65	3.88451	10	3.88705
76	3.87944	21	3.88201	66	3.88457	11	3.88711
77	3.87950	22	3.88207	67	3.88463	12	3.88717
78	3.87955	23	3.88213	68	3.88468	13	3.88722
79	3.87961	24	3.88218	69	3.88474	14	3.88728
80	3.87967	25	3.88224	70	3.88480	15	3.88734
81	3.87973	26	3.88230	71	3.88485	16	3.88739
82	3.87978	27	3.88235	72	3.88491	17	3.88745
83	3.87984	28	3.88241	73	3.88497	18	3.88750
84	3.87990	29	3.88247	74	3.88502	19	3.88756
85	3.87996	30	3.88252	75	3.88508	20	3.88762
86	3.88001	31	3.88258	76	3.88514	21	3.88767
87	3.88007	32	3.88264	77	3.88519	22	3.88773
88	3.88013	33	3.88270	78	3.88525	23	3.88779
89	3.88018	34	3.88275	79	3.88530	24	3.88784
90	3.88024	35	3.88281	80	3.88536	25	3.88790
91	3.88030	36	3.88287	81	3.88542	26	3.88795
92	3.88036	37	3.88292	82	3.88547	27	3.88801
93	3.88041	38	3.88298	83	3.88553	28	3.88807
94	3.88047	39	3.88304	84	3.88559	29	3.88812
95	3.88053	40	3.88309	85	3.88564	30	3.88818
96	3.88059	41	3.88315	86	3.88570	31	3.88824
97	3.88064	42	3.88321	87	3.88576	32	3.88829
98	3.88070	43	3.88326	88	3.88581	33	3.88835
99	3.88076	44	3.88332	89	3.88587	34	3.88840
7600	3.88081	45	3.88338	90	3.88593	35	3.88846
7601	3.88087	46	3.88343	91	3.88598	36	3.88852
02	3.88093	47	3.88349	92	3.88604	37	3.88857
03	3.88099	48	3.88355	93	3.88610	38	3.88863
04	3.88104	49	3.88360	94	3.88615	39	3.88868
05	3.88110	50	3.88366	95	3.88621	40	3.88874

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
7741	3.88880	7786	3.89131	7831	3.89382	7876	3.89631
42	3.88885	87	3.89137	32	3.89387	77	3.89636
43	3.88891	88	3.89143	33	3.89393	78	3.89642
44	3.88897	89	3.89148	34	3.89398	79	3.89647
45	3.88902	90	3.89154	35	3.89404	80	3.89653
46	3.88908	91	3.89159	36	3.89409	81	3.89658
47	3.88913	92	3.89165	37	3.89415	82	3.89664
48	3.88919	93	3.89170	38	3.89421	83	3.89669
49	3.88925	94	3.89176	39	3.89426	84	3.89675
50	3.88930	95	3.89182	40	3.89432	85	3.89680
51	3.88936	96	3.89187	41	3.89437	86	3.89686
52	3.88941	97	3.89193	42	3.89443	87	3.89691
53	3.88947	98	3.89198	43	3.89448	88	3.89697
54	3.88953	99	3.89204	44	3.89454	89	3.89702
55	3.88958	7800	3.89209	45	3.89459	90	3.89708
56	3.88964	7801	3.89215	46	3.89465	91	3.89713
57	3.88969	02	3.89221	47	3.89470	92	3.89719
58	3.88975	03	3.89226	48	3.89476	93	3.89724
59	3.88981	04	3.89232	49	3.89481	94	3.89730
60	3.88986	05	3.89237	50	3.89487	95	3.89735
61	3.88992	06	3.89243	51	3.89493	96	3.89741
62	3.88997	07	3.89248	52	3.89498	97	3.89746
63	3.89003	08	3.89254	53	3.89504	98	3.89752
64	3.89009	09	3.89260	54	3.89509	99	3.89757
65	3.89014	10	3.89265	55	3.89515	7900	3.89763
66	3.89020	11	3.89271	56	3.89520	7901	3.89768
67	3.89025	12	3.89276	57	3.89526	02	3.89774
68	3.89031	13	3.89282	58	3.89531	03	3.89779
69	3.89037	14	3.89287	59	3.89537	04	3.89785
70	3.89042	15	3.89293	60	3.89542	05	3.89790
71	3.89048	16	3.89298	61	3.89548	06	3.89796
72	3.89053	17	3.89304	62	3.89553	07	3.89801
73	3.89059	18	3.89310	63	3.89559	08	3.89807
74	3.89064	19	3.89315	64	3.89564	09	3.89812
75	3.89070	20	3.89321	65	3.89570	10	3.89818
76	3.89076	21	3.89326	66	3.89575	11	3.89823
77	3.89081	22	3.89332	67	3.89581	12	3.89829
78	3.89087	23	3.89337	68	3.89586	13	3.89834
79	3.89092	24	3.89343	69	3.89592	14	3.89840
80	3.89098	25	3.89348	70	3.89597	15	3.89845
81	3.89104	26	3.89354	71	3.89603	16	3.89851
82	3.89109	27	3.89360	72	3.89609	17	3.89856
83	3.89115	28	3.89365	73	3.89614	18	3.89862
84	3.89120	29	3.89371	74	3.89620	19	3.89867
85	3.89126	30	3.89376	75	3.89625	20	3.89873

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
7921	3.89878	7966	3.90124	8011	3.90369	8056	3.90612
22	3.89883	67	3.90129	12	3.90374	57	3.90617
23	3.89889	68	3.90135	13	3.90380	58	3.90623
24	3.89894	69	3.90140	14	3.90385	59	3.90628
25	3.89900	70	3.90146	15	3.90390	60	3.90634
26	3.89905	71	3.90151	16	3.90396	61	3.90639
27	3.89911	72	3.90157	17	3.90401	62	3.90644
28	3.89916	73	3.90162	18	3.90407	63	3.90650
29	3.89922	74	3.90168	19	3.90412	64	3.90655
30	3.89927	75	3.90173	20	3.90417	65	3.90660
31	3.89933	76	3.90179	21	3.90423	66	3.90666
32	3.89938	77	3.90184	22	3.90428	67	3.90671
33	3.89944	78	3.90189	23	3.90434	68	3.90677
34	3.89949	79	3.90195	24	3.90439	69	3.90682
35	3.89955	80	3.90200	25	3.90445	70	3.90687
36	3.89960	81	3.90206	26	3.90450	71	3.90693
37	3.89966	82	3.90211	27	3.90455	72	3.90698
38	3.89971	83	3.90217	28	3.90461	73	3.90704
39	3.89977	84	3.90222	29	3.90466	74	3.90709
40	3.89982	85	3.90227	30	3.90472	75	3.90714
41	3.89988	86	3.90233	31	3.90477	76	3.90720
42	3.89993	87	3.90238	32	3.90482	77	3.90725
43	3.89998	88	3.90244	33	3.90488	78	3.90730
44	3.90004	89	3.90249	34	3.90493	79	3.90736
45	3.90009	90	3.90255	35	3.90499	80	3.90741
46	3.90015	91	3.90260	36	3.90504	81	3.90747
47	3.90020	92	3.90266	37	3.90509	82	3.90752
48	3.90026	93	3.90271	38	3.90515	83	3.90757
49	3.90031	94	3.90276	39	3.90520	84	3.90763
50	3.90037	95	3.90282	40	3.90526	85	3.90768
51	3.90042	96	3.90287	41	3.90531	86	3.90773
52	3.90048	97	3.90293	42	3.90536	87	3.90779
53	3.90053	98	3.90298	43	3.90542	88	3.90784
54	3.90059	99	3.90304	44	3.90547	89	3.90789
55	3.90064	8000	3.90309	45	3.90553	90	3.90795
56	3.90069	8001	3.90314	46	3.90558	91	3.90800
57	3.90075	02	3.90320	47	3.90563	92	3.90806
58	3.90080	03	3.90325	48	3.90569	93	3.90811
59	3.90086	04	3.90331	49	3.90574	94	3.90816
60	3.90091	05	3.90336	50	3.90580	95	3.90822
61	3.90097	06	3.90342	51	3.90585	96	3.90827
62	3.90102	07	3.90347	52	3.90590	97	3.90832
63	3.90108	08	3.90352	53	3.90596	98	3.90838
64	3.90113	09	3.90358	54	3.90601	99	3.90843
65	3.90119	10	3.90363	55	3.90607	8100	3.90849

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
8101	3.90854	8146	3.91094	8191	3.91334	8236	3.91572
02	3.90859	47	3.91100	92	3.91339	37	3.91577
03	3.90865	48	3.91105	93	3.91344	38	3.91582
04	3.90870	49	3.91110	94	3.91350	39	3.91587
05	3.90875	50	3.91116	95	3.91355	40	3.91593
06	3.90881	51	3.91121	96	3.91360	41	3.91598
07	3.90886	52	3.91126	97	3.91365	42	3.91603
08	3.90891	53	3.91132	98	3.91371	43	3.91609
09	3.90897	54	3.91137	99	3.91376	44	3.91614
10	3.90902	55	3.91142	8200	3.91381	45	3.91619
11	3.90907	56	3.91148	8201	3.91387	46	3.91624
12	3.90913	57	3.91153	02	3.91392	47	3.91630
13	3.90918	58	3.91158	03	3.91397	48	3.91635
14	3.90924	59	3.91164	04	3.91403	49	3.91640
15	3.90929	60	3.91169	05	3.91408	50	3.91645
16	3.90934	61	3.91174	06	3.91413	51	3.91651
17	3.90940	62	3.91180	07	3.91418	52	3.91656
18	3.90945	63	3.91185	08	3.91424	53	3.91661
19	3.90950	64	3.91190	09	3.91429	54	3.91666
20	3.90956	65	3.91196	10	3.91434	55	3.91672
21	3.90961	66	3.91201	11	3.91440	56	3.91677
22	3.90966	67	3.91206	12	3.91445	57	3.91682
23	3.90972	68	3.91212	13	3.91450	58	3.91687
24	3.90977	69	3.91217	14	3.91455	59	3.91693
25	3.90982	70	3.91222	15	3.91461	60	3.91698
26	3.90988	71	3.91228	16	3.91466	61	3.91703
27	3.90993	72	3.91233	17	3.91471	62	3.91709
28	3.90998	73	3.91238	18	3.91477	63	3.91714
29	3.91004	74	3.91243	19	3.91482	64	3.91719
30	3.91009	75	3.91249	20	3.91487	65	3.91724
31	3.91014	76	3.91254	21	3.91492	66	3.91730
32	3.91020	77	3.91259	22	3.91498	67	3.91735
33	3.91025	78	3.91265	23	3.91503	68	3.91740
34	3.91030	79	3.91270	24	3.91508	69	3.91745
35	3.91036	80	3.91275	25	3.91514	70	3.91751
36	3.91041	81	3.91281	26	3.91519	71	3.91756
37	3.91046	82	3.91286	27	3.91524	72	3.91761
38	3.91052	83	3.91291	28	3.91529	73	3.91766
39	3.91057	84	3.91297	29	3.91535	74	3.91772
40	3.91062	85	3.91302	30	3.91540	75	3.91777
41	3.91068	86	3.91307	31	3.91545	76	3.91781
42	3.91073	87	3.91312	32	3.91551	77	3.91787
43	3.91078	88	3.91318	33	3.91556	78	3.91793
44	3.91084	89	3.91323	34	3.91561	79	3.91798
45	3.91089	90	3.91328	35	3.91566	80	3.91893

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
8281	3.91808	8326	3.92044	8371	3.92278	8416	3.92511
82	3.91814	27	3.92049	72	3.92283	17	3.92516
83	3.91819	28	3.92054	73	3.92288	18	3.92521
84	3.91824	29	3.92059	74	3.92293	19	3.92526
85	3.91829	30	3.92065	75	3.92298	20	3.92531
86	3.91834	31	3.92070	76	3.92304	21	3.92536
87	3.91840	32	3.92075	77	3.92309	22	3.92542
88	3.91845	33	3.92080	78	3.92314	23	3.92547
89	3.91850	34	3.92085	79	3.92319	24	3.92552
90	3.91855	35	3.92091	80	3.92324	25	3.92557
91	3.91861	36	3.92096	81	3.92330	26	3.92562
92	3.91866	37	3.92101	82	3.92335	27	3.92567
93	3.91871	38	3.92106	83	3.92340	28	3.92572
94	3.91876	39	3.92111	84	3.92345	29	3.92578
95	3.91882	40	3.92117	85	3.92350	30	3.92583
96	3.91887	41	3.92122	86	3.92355	31	3.92588
97	3.91892	42	3.92127	87	3.92361	32	3.92593
98	3.91897	43	3.92132	88	3.92366	33	3.92598
99	3.91903	44	3.92137	89	3.92371	34	3.92603
8300	3.91908	45	3.92143	90	3.92376	35	3.92609
8301	3.91913	46	3.92148	91	3.92381	36	3.92614
02	3.91918	47	3.92153	92	3.92387	37	3.92619
03	3.91924	48	3.92158	93	3.62392	38	3.92624
04	3.91929	49	3.92163	94	3.92397	39	3.92629
05	3.91934	50	3.92169	95	3.92402	40	3.92634
06	3.91939	51	3.92174	96	3.92407	41	3.92639
07	3.91944	52	3.92179	97	3.92412	42	3.92645
08	3.91950	53	3.92184	98	3.92418	43	3.92650
09	3.91955	54	3.92189	99	3.92423	44	3.92655
10	3.91960	55	3.92195	8400	3.92428	45	3.92660
11	3.91965	56	3.92200	8401	3.92433	46	3.92665
12	3.91971	57	3.92205	02	3.92438	47	3.92670
13	3.91976	58	3.92210	03	3.92443	48	3.92675
14	3.91981	59	3.92215	04	3.92449	49	3.92681
15	3.91986	60	3.92221	05	3.92454	50	3.92686
16	3.91991	61	3.92226	06	3.92459	51	3.92691
17	3.91997	62	3.92231	07	3.92464	52	3.92696
18	3.92002	63	3.92236	08	3.92469	53	3.92701
19	3.92007	64	3.92241	09	3.92474	54	3.92706
20	3.92012	65	3.92247	10	3.92480	55	3.92711
21	3.92018	66	3.92252	11	3.92485	56	3.92717
22	3.92023	67	3.92257	12	3.92490	57	3.92722
23	3.92028	68	3.92262	13	3.92495	58	3.92727
24	3.92033	69	3.92267	14	3.92500	59	3.92732
25	3.92038	70	3.9227[illegible]	15	3.9250[illegible]	60	3.92727

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
8461	3.92742	8506	3.92973	8551	3.93201	8596	3.93430
62	3.92747	07	3.92978	52	3.93207	97	3.93435
63	3.92752	08	3.92983	53	3.93212	98	3.93440
64	3.92758	09	3.92988	54	3.93217	99	3.93445
65	3.92763	10	3.92993	55	3.93222	8600	3.93450
66	3.92768	11	3.92998	56	3.93227	8601	3.93455
67	3.92773	12	3.93003	57	3.93232	02	3.93460
68	3.92778	13	3.93008	58	3.93237	03	3.93465
69	3.92783	14	3.93013	59	3.93242	04	3.93470
70	3.92788	15	3.93018	60	3.93247	05	3.93475
71	3.92793	16	3.93024	61	3.93252	06	3.93480
72	3.92799	17	3.93029	62	3.93258	07	3.93485
73	3.92804	18	3.93034	63	3.93263	08	3.93490
74	3.92809	19	3.93039	64	3.93268	09	3.93495
75	3.92814	20	3.93044	65	3.93273	10	3.93500
76	3.92819	21	3.93049	66	3.93278	11	3.93505
77	3.92824	22	3.93054	67	3.93283	12	3.93510
78	3.92829	23	3.93059	68	3.93288	13	3.93515
79	3.92834	24	3.93064	69	3.93293	14	3.93520
80	3.92840	25	3.93069	70	3.93298	15	3.93526
81	3.92845	26	3.93075	71	3.93303	16	3.93531
82	3.92850	27	3.93080	72	3.93308	17	3.93536
83	3.92855	28	3.93085	73	3.93313	18	3.93541
84	3.92860	29	3.93090	74	3.93318	19	3.93546
85	3.92865	30	3.93095	75	3.93323	20	3.93551
86	3.92870	31	3.93100	76	3.93328	21	3.93556
87	3.92875	32	3.93105	77	3.93334	22	3.93561
88	3.92881	33	3.93110	78	3.93339	23	3.93566
89	3.92886	34	3.93115	79	3.93344	24	3.93571
90	3.92891	35	3.93120	80	3.93349	25	3.93576
91	3.92896	36	3.93125	81	3.93354	26	3.93581
92	3.92901	37	3.93131	82	3.93359	27	3.93586
93	3.92906	38	3.93136	83	3.93364	28	3.93591
94	3.92911	39	3.93141	84	3.93369	29	3.93596
95	3.92916	40	3.93146	85	3.93374	30	3.93601
96	3.92921	41	3.93151	86	3.93379	31	3.93606
97	3.92927	42	3.93156	87	3.93384	32	3.93611
98	3.92932	43	3.93161	88	3.93389	33	3.93616
99	3.92937	44	3.93166	89	3.93394	34	3.93621
8500	3.92942	45	3.93171	90	3.93399	35	3.93626
8501	3.92947	46	3.93176	91	3.93404	36	3.93631
02	3.92952	47	3.93181	92	3.93409	37	3.93636
03	3.92957	48	3.93186	93	3.93414	38	3.93641
04	3.92962	49	3.93192	94	3.93420	39	3.93646
05	3.92967	50	3.93197	95	3.93425	40	3.93651

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
8641	3·93656	8686	3·93882	8731	3·94106	8776	3·94330
42	3·93661	87	3·93887	32	3·94111	77	3·94335
43	3·93666	88	3·93892	33	3·94116	78	3·94340
44	3·93671	89	3·93897	34	3·94121	79	3·94345
45	3·93677	90	3·93902	35	3·94126	80	3·94349
46	3·93682	91	3·93907	36	3·94131	81	3·94354
47	3·93687	92	3·93912	37	3·94136	82	3·94359
48	3·93692	93	3·93917	38	3·94141	83	3·94364
49	3·93697	94	3·93922	39	3·94146	84	3·94369
50	3·93702	95	3·93927	40	3·94151	85	3·94374
51	3·93707	96	3·93932	41	3·94156	86	3·94379
52	3·93712	97	3·93937	42	3·94161	87	3·94384
53	3·93717	98	3·93942	43	3·94166	88	3·94389
54	3·93722	99	3·93947	44	3·94171	89	3·94394
55	3·93727	8700	3·93952	45	3·94176	90	3·94399
56	3·93732	8701	3·93957	46	3·94181	91	3·94404
57	3·93737	02	3·93962	47	3·94186	92	3·94409
58	3·93742	03	3·93967	48	3·94191	93	3·94414
59	3·93747	04	3·93972	49	3·94196	94	3·94419
60	3·93752	05	3·93977	50	3·94201	95	3·94424
61	3·93757	06	3·93982	51	3·94206	96	3·94429
62	3·93762	07	3·93987	52	3·94211	97	3·94433
63	3·93767	08	3·93992	53	3·94216	98	3·94438
64	3·93772	09	3·93997	54	3·94221	99	3·94443
65	3·93777	10	3·94002	55	3·94226	8800	3·94448
66	3·93782	11	3·94007	56	3·94231	8801	3·94453
67	3·93787	12	3·94012	57	3·94236	02	3·94458
68	3·93792	13	3·94017	58	3·94240	03	3·94463
69	3·93797	14	3·94022	59	3·94245	04	3·94468
70	3·93802	15	3·94027	60	3·94250	05	3·94473
71	3·93807	16	3·94032	61	3·94255	06	3·94478
72	3·93812	17	3·94037	62	3·94260	07	3·94483
73	3·93817	18	3·94042	63	3·94265	08	3·94488
74	3·93822	19	3·94047	64	3·94270	09	3·94493
75	3·93827	20	3·94052	65	3·94275	10	3·94498
76	3·93832	21	3·94057	66	3·94280	11	3·94503
77	3·93837	22	3·94062	67	3·94285	12	3·94507
78	3·93842	23	3·94067	68	3·94290	13	3·94512
79	3·93847	24	3·94072	69	3·94295	14	3·94517
80	3·93852	25	3·94077	70	3·94300	15	3·94522
81	3·93857	26	3·94082	71	3·94305	16	3·94527
82	3·93862	27	3·94087	72	3·94310	17	3·94532
83	3·93867	28	3·94091	73	3·94315	18	3·94537
84	3·93872	29	3·94096	74	3·94320	19	3·94542
85	3·93877	30	3·94101	75	3·94325	20	3·94547

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
8821	3·94552	8866	3·94773	8911	3·94993	8956	3·95211
22	3·94557	67	3·94778	12	3·94998	57	3·95216
23	3·94562	68	3·94783	13	3·95002	58	3·95221
24	3·94567	69	3·94787	14	3·95007	59	3·95226
25	3·94571	70	3·94792	15	3·95012	60	3·95231
26	3·94576	71	3·94797	16	3·95017	61	3·95236
27	3·94581	72	3·94802	17	3·95022	62	3·95240
28	3·94586	73	3·94807	18	3·95027	63	3·95245
29	3·94591	74	3·94812	19	3·95032	64	3·95250
30	3·94596	75	3·94817	20	3·95036	65	3·95255
31	3·94601	76	3·94822	21	3·95041	66	3·95260
32	3·94606	77	3·94827	22	3·95046	67	3·95265
33	3·94611	78	3·94832	23	3·95051	68	3·95270
34	3·94616	79	3·94836	24	3·95056	69	3·95274
35	3·94621	80	3·94841	25	3·95061	70	3·95279
36	3·94626	81	3·94846	26	3·95066	71	3·95284
37	3·94630	82	3·94851	27	3·95071	72	3·95289
38	3·94635	83	3·94856	28	3·95075	73	3·95294
39	3·94640	84	3·94861	29	3·95080	74	3·95299
40	3·94645	85	3·94866	30	3·95085	75	3·95303
41	3·64650	86	3·94871	31	3·95090	76	3·95308
42	3·94655	87	3·94876	32	3·95095	77	3·95313
43	3·94660	88	3·94880	33	3·95100	78	3·95318
44	3·94665	89	3·94885	34	3·95105	79	3·95323
45	3·94670	90	3·94890	35	3·95109	80	3·95328
46	3·94675	91	3·94895	36	3·95114	81	3·95332
47	3·94680	92	3·94900	37	3·95119	82	3·95337
48	3·94685	93	3·94905	38	3·95124	83	3·95342
49	3·94689	94	3·94910	39	3·95129	84	3·95347
50	3·94694	95	3·94915	40	3·95134	85	3·95352
51	3·94699	96	3·94919	41	3·95139	86	3·95357
52	3·94704	97	3·94924	42	3·95143	87	3·95361
53	3·94709	98	3·94929	43	3·95148	88	3·95366
54	3·94714	99	3·94934	44	3·95153	89	3·95371
55	3·94719	8900	3·94939	45	3·95158	90	3·95376
56	3·94724	8901	3·94944	46	3·95163	91	3·95381
57	3·94729	02	3·94949	47	3·95168	92	3·95386
58	3·94734	03	3·94954	48	3·95173	93	3·95390
59	3·94738	04	3·94959	49	3·95177	94	3·95395
60	3·94743	05	3·94963	50	3·95182	95	3·95400
61	3·94748	06	3·94968	51	3·95187	96	3·95405
62	3·94753	07	3·94973	52	3·95192	97	3·95410
63	3·94758	08	3·94978	53	3·95197	98	3·95415
64	3·94763	09	3·94983	54	3·95202	99	3·95419
65	3·94768	10	3·94988	55	3·95207	9000	3·95424

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
9001	3.95429	9046	3.95646	9091	3.95861	9136	3.96076
02	3.95434	47	3.95650	92	3.95866	37	3.96080
03	3.95439	48	3.95655	93	3.95871	38	3.96085
04	3.95444	49	3.95660	94	3.95875	39	3.96090
05	3.95448	50	3.95665	95	3.95880	40	3.96095
06	3.95453	51	3.95670	96	3.95885	41	3.96099
07	3.95458	52	3.95675	97	3.95890	42	3.96104
08	3.95463	53	3.95679	98	3.95895	43	3.96109
09	3.95468	54	3.95684	99	3.95899	44	3.96114
10	3.95472	55	3.95689	9100	3.95904	45	3.96118
11	3.95477	56	3.95694	9101	3.95909	46	3.96123
12	3.95482	57	3.95698	02	3.95914	47	3.96128
13	3.95487	58	3.95703	03	3.95918	48	3.96133
14	3.95492	59	3.95708	04	3.95923	49	3.96137
15	3.95497	60	3.95713	05	3.95928	50	3.96142
16	3.95501	61	3.95718	06	3.95933	51	3.96147
17	3.95506	62	3.95722	07	3.95938	52	3.96152
18	3.95511	63	3.95727	08	3.95942	53	3.96156
19	3.95516	64	3.95732	09	3.95947	54	3.96161
20	3.95521	65	3.95737	10	3.95952	55	3.96166
21	3.95525	66	3.95742	11	3.95957	56	3.96171
22	3.95530	67	3.95746	12	3.95961	57	3.96175
23	3.95535	68	3.95751	13	3.95966	58	3.96180
24	3.95540	69	3.95756	14	3.95971	59	3.96185
25	3.95545	70	3.95761	15	3.95976	60	3.96190
26	3.95550	71	3.95766	16	3.95980	61	3.96194
27	3.95554	72	3.95770	17	3.95985	62	3.96199
28	3.95559	73	3.95775	18	3.95990	63	3.96204
29	3.95564	74	3.95780	19	3.95995	64	3.96209
30	3.95569	75	3.95785	20	3.95999	65	3.96213
31	3.95574	76	3.95789	21	3.96004	66	3.96218
32	3.95578	77	3.95794	22	3.96009	67	3.96223
33	3.95583	78	3.95799	23	3.96014	68	3.96227
34	3.95588	79	3.95804	24	3.96019	69	3.96232
35	3.95593	80	3.95809	25	3.96023	70	3.96237
36	3.95598	81	3.95813	26	3.96028	71	3.96242
37	3.95602	82	3.95818	27	3.96033	72	3.96246
38	3.95607	83	3.95823	28	3.96038	73	3.96251
39	3.95612	84	3.95828	29	3.96042	74	3.96256
40	3.95617	85	3.95832	30	3.96047	75	3.96261
41	3.95622	86	3.95837	31	3.96052	76	3.96265
42	3.95626	87	3.95842	32	3.96057	77	3.96270
43	3.95631	88	3.95847	33	3.96061	78	3.96275
44	3.95636	89	3.95852	34	3.96066	79	3.96280
45	3.95641	90	3.95856	35	3.96071	80	3.96284

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
9181	3.96289	9226	3.96501	9271	3.96713	9316	3.96923
82	3.96294	27	3.96506	72	3.96717	17	3.96928
83	3.96298	28	3.96511	73	3.96722	18	3.96932
84	3.96303	29	3.96515	74	3.96727	19	3.96937
85	3.96308	30	3.96520	75	3.96731	20	3.96942
86	3.96313	31	3.96525	76	3.96736	21	3.96946
87	3.96317	32	3.96530	77	3.96741	22	3.96951
88	3.96322	33	3.96534	78	3.96745	23	3.96956
89	3.96327	34	3.96539	79	3.96750	24	3.96960
90	3.96332	35	3.96544	80	3.96755	25	3.96965
91	3.96336	36	3.96548	81	3.96759	26	3.96970
92	3.96341	37	3.96553	82	3.96764	27	3.96974
93	3.96346	38	3.96558	83	3.96769	28	3.96979
94	3.96350	39	3.96563	84	3.96774	29	3.96984
95	3.96355	40	3.96567	85	3.96778	30	3.96988
96	3.96360	41	3.96572	86	3.96783	31	3.96993
97	3.96365	42	3.96577	87	3.96788	32	3.96997
98	3.96369	43	3.96581	88	3.96792	33	3.97002
99	3.96374	44	3.96586	89	3.96797	34	3.97007
9200	3.96379	45	3.96591	90	3.96802	35	3.97011
9201	3.96384	46	3.96595	91	3.96806	36	3.97016
02	3.96388	47	3.96600	92	3.96811	37	3.97021
03	3.96393	48	3.96605	93	3.96816	38	3.97025
04	3.96398	49	3.96609	94	3.96820	39	3.97030
05	3.96402	50	3.96614	95	3.96825	40	3.97035
06	3.96407	51	3.96619	96	3.96830	41	3.97039
07	3.96412	52	3.96624	97	3.96834	42	3.97044
08	3.96417	53	3.96628	98	3.96839	43	3.97049
09	3.96421	54	3.96633	99	3.96844	44	3.97053
10	3.96426	55	3.96638	9300	3.96848	45	3.97058
11	3.96431	56	3.96642	9301	3.96853	46	3.97063
12	3.96435	57	3.96647	02	3.96858	47	3.97067
13	3.96440	58	3.96652	03	3.96862	48	3.97072
14	3.96445	59	3.96656	04	3.96867	49	3.97077
15	3.96450	60	3.96661	05	3.96872	50	3.97081
16	3.96454	61	3.96666	06	3.96876	51	3.97086
17	3.96459	62	3.96670	07	3.96881	52	3.97090
18	3.96464	63	3.96675	08	3.96886	53	3.97095
19	3.96468	64	3.96680	09	3.96890	54	3.97100
20	3.96473	65	3.96685	10	3.96895	55	3.97104
21	3.96478	66	3.96689	11	3.96900	56	3.97109
22	3.96483	67	3.96694	12	3.96904	57	3.97114
23	3.96487	68	3.96699	13	3.96909	58	3.97118
24	3.96492	69	3.96703	14	3.96914	59	3.97123
25	3.96497	70	3.96708	15	3.96918	60	3.97128

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
9361	3.97132	9406	3.97341	9451	3.97548	9496	3.97754
62	3.97137	07	3.97345	52	3.97552	97	3.97759
63	3.97142	08	3.97350	53	3.97557	98	3.97763
64	3.97146	09	3.97355	54	3.97562	99	3.97768
65	3.97151	10	3.97359	55	3.97566	9500	3.97772
66	3.97155	11	3.97364	56	3.97571	9501	3.97777
67	3.97160	12	3.97368	57	3.97575	02	3.97782
68	3.97165	13	3.97373	58	3.97580	03	3.97786
69	3.97169	14	3.97377	59	3.97585	04	3.97791
70	3.97174	15	3.97382	60	3.97589	05	3.97795
71	3.97179	16	3.97387	61	3.97594	06	3.97800
72	3.97183	17	3.97391	62	3.97598	07	3.97804
73	3.97188	18	3.97396	63	3.97603	08	3.97809
74	3.97192	19	3.97400	64	3.97607	09	3.97813
75	3.97197	20	3.97405	65	3.97612	10	3.97818
76	3.97202	21	3.97410	66	3.97617	11	3.97823
77	3.97206	22	3.97414	67	3.97621	12	3.97827
78	3.97211	23	3.97419	68	3.97626	13	3.97832
79	3.97216	24	3.97424	69	3.97630	14	3.97836
80	3.97220	25	3.97428	70	3.97635	15	3.97841
81	3.97225	26	3.97433	71	3.97640	16	3.97845
82	3.97230	27	3.97437	72	3.97644	17	3.97850
83	3.97234	28	3.97442	73	3.97649	18	3.97855
84	3.97239	29	3.97447	74	3.97653	19	3.97859
85	3.97243	30	3.97451	75	3.97658	20	3.97864
86	3.97248	31	3.97456	76	3.97663	21	3.97868
87	3.97253	32	3.97460	77	3.97667	22	3.97873
88	3.97257	33	3.97465	78	3.97672	23	3.97877
89	3.97262	34	3.97470	79	3.97676	24	3.97882
90	3.97267	35	3.97474	80	3.97681	25	3.97887
91	3.97271	36	3.97479	81	3.97685	26	3.97891
92	3.97276	37	3.97483	82	3.97690	27	3.97896
93	3.97280	38	3.97488	83	3.97695	28	3.97900
94	3.97285	39	3.97493	84	3.97699	29	3.97905
95	3.97290	40	3.97497	85	3.97704	30	3.97909
96	3.97294	41	3.97502	86	3.97708	31	3.97914
97	3.97299	42	3.97506	87	3.97713	32	3.97918
98	3.97304	43	3.97511	88	3.97717	33	3.97923
99	3.97308	44	3.97516	89	3.97722	34	3.97928
9400	3.97313	45	3.97520	90	3.97727	35	3.97932
9401	3.97317	46	3.97525	91	3.97731	36	3.97937
02	3.97322	47	3.97529	92	3.97736	37	3.97941
03	3.97327	48	3.97534	93	3.97740	38	3.97946
04	3.97331	49	3.97539	94	3.97745	39	3.97950
05	3.97336	50	3.97543	95	3.97750	40	3.97955

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
9541	3.97959	9586	3.98164	9631	3.98367	9676	3.98570
42	3.97964	87	3.98168	32	3.98372	77	3.98574
43	3.97968	88	3.98173	33	3.98376	78	3.98579
44	3.97973	89	3.98177	34	3.98381	79	3.98583
45	3.97978	90	3.98182	35	3.98385	80	3.98588
46	3.97982	91	3.98186	36	3.98390	81	3.98592
47	3.97987	92	3.98191	37	3.98394	82	3.98597
48	3.97991	93	3.98195	38	3.98399	83	3.98601
49	3.97996	94	3.98200	39	3.98403	84	3.98605
50	3.98000	95	3.98205	40	3.98408	85	3.98610
51	3.98005	96	3.98209	41	3.98412	86	3.98614
52	3.98009	97	3.98214	42	3.98417	87	3.98619
53	3.98014	98	3.98218	43	3.98421	88	3.98623
54	3.98019	99	3.98223	44	3.98426	89	3.98628
55	3.98023	9600	3.98227	45	3.98430	90	3.98632
56	3.98028	9601	3.98232	46	3.98435	91	3.98637
57	3.98032	02	3.98236	47	3.98439	92	3.98641
58	3.98037	03	3.98241	48	3.98444	93	3.98646
59	3.98041	04	3.98245	49	3.98448	94	3.98650
60	3.98046	05	3.98250	50	3.98453	95	3.98655
61	3.98050	06	3.98254	51	3.98457	96	3.98659
62	3.98055	07	3.98259	52	3.98462	97	3.98664
63	3.98059	08	3.98263	53	3.98466	98	3.98668
64	3.98064	09	3.98268	54	3.98471	99	3.98673
65	3.98069	10	3.98272	55	3.98475	9700	3.98677
66	3.98073	11	3.98277	56	3.98480	9701	3.98682
67	3.98078	12	3.98281	57	3.98484	02	3.98686
68	3.98082	13	3.98286	58	3.98489	03	3.98691
69	3.98087	14	3.98290	59	3.98493	04	3.98695
70	3.98091	15	3.98295	60	3.98498	05	3.98700
71	3.98096	16	3.98299	61	3.98502	06	3.98704
72	3.98100	17	3.98304	62	3.98507	07	3.98709
73	3.98105	18	3.98308	63	3.98511	08	3.98713
74	3.98109	19	3.98313	64	3.98516	09	3.98717
75	3.98114	20	3.98318	65	3.98520	10	3.98722
76	3.98118	21	3.98322	66	3.98525	11	3.98726
77	3.98123	22	3.98327	67	3.98529	12	3.98731
78	3.98127	23	3.98331	68	3.98534	13	3.98735
79	3.98132	24	3.98336	69	3.98538	14	3.98740
80	3.98137	25	3.98340	70	3.98543	15	3.98744
81	3.98141	26	3.98345	71	3.98547	16	3.98749
82	3.98146	27	3.98349	72	3.98552	17	3.98753
83	3.98150	28	3.98354	73	3.98556	18	3.98758
84	3.98155	29	3.98358	74	3.98561	19	3.98762
85	3.98159	30	3.98363	75	3.98565	20	3.98767

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
9721	3.98771	9766	3.98972	9811	3.99171	9856	3.99370
22	3.98776	67	3.98976	12	3.99176	57	3.99374
23	3.98780	68	3.98981	13	3.99180	58	3.99379
24	3.98784	69	3.98985	14	3.99185	59	3.99383
25	3.98789	70	3.98989	15	3.99189	60	3.99388
26	3.98793	71	3.98994	16	3.99193	61	3.99392
27	3.98798	72	3.98998	17	3.99198	62	3.99397
28	3.98802	73	3.99003	18	3.99202	63	3.99401
29	3.98807	74	3.99007	19	3.99207	64	3.99405
30	3.98811	75	3.99012	20	3.99211	65	3.99410
31	3.98816	76	3.99016	21	3.99216	66	3.99414
32	3.98820	77	3.99021	22	3.99220	67	3.99419
33	3.98825	78	3.99025	23	3.99224	68	3.99423
34	3.98829	79	3.99029	24	3.99229	69	3.99427
35	3.98834	80	3.99034	25	3.99233	70	3.99422
36	3.98838	81	3.99038	26	3.99238	71	3.99436
37	3.98843	82	3.99043	27	3.99242	72	3.99441
38	3.98847	83	3.99047	28	3.99247	73	3.99445
39	3.98851	84	3.99052	29	3.99251	74	3.99449
40	3.98856	85	3.99056	30	3.99255	75	3.99454
41	3.98860	86	3.99061	31	3.99260	76	3.99458
42	3.98865	87	3.99065	32	3.99264	77	3.99463
43	3.98869	88	3.99069	33	3.99269	78	3.99467
44	3.98874	89	3.99074	34	3.99273	79	3.99471
45	3.98878	90	3.99078	35	3.99277	80	3.99476
46	3.98883	91	3.99083	36	3.99282	81	3.99480
47	3.98887	92	3.99087	37	3.99286	82	3.99484
48	3.98892	93	3.99092	38	3.99291	83	3.99489
49	3.98896	94	3.99096	39	3.99295	84	3.99493
50	3.98900	95	3.99100	40	3.99300	85	3.99498
51	3.98905	96	3.99105	41	3.99304	86	3.99502
52	3.98909	97	3.99109	42	3.99308	87	3.99506
53	3.98914	98	3.99114	43	3.99313	88	3.99511
54	3.98918	99	3.99118	44	3.99317	89	3.99515
55	3.98922	9800	3.99123	45	3.99322	90	3.99520
56	3.98927	9801	3.99127	46	3.99326	91	3.99524
57	3.98932	02	3.99131	47	3.99330	92	3.99528
58	3.98936	03	3.99136	48	3.99335	93	3.99533
59	3.98941	04	3.99140	49	3.99339	94	3.99537
60	3.98945	05	3.99145	50	3.99344	95	3.99542
61	3.98949	06	3.99149	51	3.99348	96	3.99546
62	3.98954	07	3.99154	52	3.99352	97	3.99550
63	3.98958	08	3.99158	53	3.99357	98	3.99555
64	3.98963	09	3.99162	54	3.99361	99	3.99559
65	3.98967	10	3.99166	55	3.99366	9900	3.99564

N.	Logar.	N.	Logar.	N.	Logar.	N.	Logar.
9901	3.99568	9926	3.99677	9951	3.99787	9976	3.99896
02	3.99572	27	3.99682	52	3.99791	77	3.99900
03	3.99577	28	3.99686	53	3.99795	78	3.99904
04	3.99581	29	3.99691	54	3.99800	79	3.99909
05	3.99585	30	3.99695	55	3.99804	80	3.99913
06	3.99590	31	3.99699	56	3.99808	81	3.99917
07	3.99594	32	3.99704	57	3.99813	82	3.99922
08	3.99599	33	3.99708	58	3.99817	83	3.99926
09	3.99603	34	3.99712	59	3.99822	84	3.99930
10	3.99607	35	3.99717	60	3.99826	85	3.99935
11	3.99612	36	3.99721	61	3.99830	86	3.99939
12	3.99616	37	3.99726	62	3.99835	87	3.99944
13	3.99621	38	3.99730	63	3.99839	88	3.99948
14	3.99625	39	3.99734	64	3.99843	89	3.99952
15	3.99629	40	3.99739	65	3.99848	90	3.99957
16	3.99634	41	3.99743	66	3.99852	91	3.99961
17	3.99638	42	3.99747	67	3.99856	92	3.99965
18	3.99642	43	3.99752	68	3.99861	93	3.99970
19	3.99647	44	3.99756	69	3.99865	94	3.99974
20	3.99651	45	3.99760	70	3.99870	95	3.99978
21	3.99656	46	3.99765	71	3.99874	96	3.99983
22	3.99660	47	3.99769	72	3.99878	97	3.99987
23	3.99664	48	3.99774	73	3.99883	98	3.99991
24	3.99669	49	3.99778	74	3.99887	99	3.99996
25	3.99673	50	3.99782	75	3.99891	10000	4.00000

A

TABLE

OF

Artificial SINES, TANGENTS, and SECANTS, the Radius 10.00000; and to every Degree and Minute of the QUADRANT.

A Table of Artificial Sines,

0 Degrees.

Min.	Sine.		Tang.		Secant.		
0	0.00000	10.00000	0.00000	Infinite.	10.00000	Infinite.	60
1	6.46373	9.99999	6.46373	13.53627	10.00000	13.53627	59
2	6.76476	9.99999	6.76471	13.23524	10.00000	13.23524	58
3	6.94085	9.99999	6.94085	13.05915	10.00000	13.05915	57
4	7.06579	9.99999	7.06579	12.93421	10.00000	12.91421	56
5	7.16270	9.99999	7.16270	12.83730	10.00000	12.83730	55
6	7.24188	9.99999	7.24188	12.75812	10.00000	12.75812	54
7	7.30882	9.99999	7.30883	12.69118	10.00000	12.69118	53
8	7.36682	9.99999	7.36682	12.63318	10.00000	12.63318	52
9	7.41797	9.99999	7.41797	12.58203	10.00000	12.58203	51
10	7.46373	9.99999	7.46373	12.53627	10.00000	12.53627	50
11	7.50517	9.99999	7.50512	12.49488	10.00000	12.49488	49
12	7.54291	9.99999	7.54291	12.45709	10.00000	12.45709	48
13	7.57767	9.99999	7.57767	12.42233	10.00000	12.42233	47
14	7.60985	9.99999	7.60986	12.39014	10.00000	12.39015	46
15	7.63982	9.99999	7.63982	12.36018	10.00000	12.36018	45
16	7.66784	9.99999	7.66785	12.33215	10.00001	12.33216	44
17	7.69412	9.99999	7.69412	12.30582	10.00001	12.30583	43
18	7.71900	9.99999	7.71900	12.28100	10.00001	12.28100	42
19	7.74248	9.99999	7.74248	12.25752	10.00001	12.25752	41
20	7.76475	9.99999	7.76476	12.23524	10.00001	12.23525	40
21	7.78594	9.99999	7.78595	12.21405	10.00001	12.21406	39
22	7.80615	9.99999	7.80616	12.19385	10.00001	12.19385	38
23	7.82545	9.99999	7.82546	12.17454	10.00001	12.17455	37
24	7.84393	9.99999	7.84394	12.15606	10.00001	12.15607	36
25	7.86166	9.99999	7.86167	12.13833	10.00001	12.13834	35
26	7.87870	9.99999	7.87871	12.12129	10.00001	12.12131	34
27	7.89509	9.99999	7.89510	12.10490	10.00001	12.10492	33
28	7.91088	9.99999	7.91089	12.08911	10.00001	12.08912	32
29	7.92612	9.99998	7.92613	12.07387	10.00002	12.07388	31
30	7.94084	9.99998	7.94086	12.05914	10.00002	12.05916	30
		Sine.		Tang.		Secant.	Min.

89 Degrees.

Tangents and Secants.

0 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	7.94084	9.99998	7.94086	12.05914	10.00002	12.05916	30
31	7.95508	9.99998	7.95510	12.04490	10.00002	12.04492	29
32	7.96887	9.99998	7.96889	12.03111	10.00002	12.03113	28
33	7.98223	9.99998	7.98225	12.01775	10.00002	12.01777	27
34	7.99520	9.99998	7.99522	12.00478	10.00002	12.00480	26
35	8.00779	9.99998	8.00781	11.99219	10.00002	11.99221	25
36	8.02002	9.99998	8.02004	11.97996	10.00002	11.97998	24
37	8.03192	9.99998	8.03195	11.96806	10.00003	11.96808	23
38	8.04350	9.99997	8.04353	11.95647	10.00003	11.95650	22
39	8.05478	9.99997	8.05481	11.94519	10.00003	11.94522	21
40	8.06578	9.99997	8.06581	11.93419	10.00003	11.93422	20
41	8.07650	9.99997	8.07653	11.92347	10.00003	11.92350	19
42	8.08697	9.99997	8.08700	11.91300	10.00003	11.91304	18
43	8.09718	9.99997	8.09722	11.90278	10.00003	11.90282	17
44	8.10717	9.99996	8.10720	11.89280	10.00004	11.89283	16
45	8.11693	9.99996	8.11696	11.88304	10.00004	11.88307	15
46	8.12647	9.99996	8.12651	11.87349	10.00004	11.87353	14
47	8.13581	9.99996	8.13585	11.86415	10.00004	11.86419	13
48	8.14495	9.99996	8.14500	11.85500	10.00004	11.85505	12
49	8.15391	9.99996	8.15395	11.84605	10.00004	11.84609	11
50	8.16268	9.99995	8.16273	11.83727	10.00005	11.83732	10
51	8.17128	9.99995	8.17133	11.82867	10.00005	11.82872	9
52	8.17971	9.99995	8.17976	11.82024	10.00005	11.82029	8
53	8.18799	9.99995	8.18804	11.81196	10.00005	11.81202	7
54	8.19610	9.99995	8.19616	11.80384	10.00005	11.80390	6
55	8.20407	9.99994	8.20413	11.79587	10.00006	11.79593	5
56	8.21190	9.99994	8.21195	11.78805	10.00006	11.78811	4
57	8.21958	9.99994	8.21964	11.78036	10.00006	11.78042	3
58	8.22713	9.99994	8.22720	11.77281	10.00006	11.77287	2
59	8.23456	9.99994	8.23462	11.76538	10.00006	11.76544	1
60	8.24186	9.99993	8.24192	11.75808	10.00007	11.75815	0
		Sine.		Tang.		Secant.	Min.

89 *Degrees.*

A Table of Artificial Sines,

1 *Degree.*

Min.	Sine.		Tang.		Secant.		
0	8.24186	9.99993	8.24192	11.75808	10.00007	11.75815	60
1	8.24903	9.99993	8.24910	11.75090	10.00007	11.75098	59
2	8.25609	9.99993	8.25617	11.74384	10.00007	11.74391	58
3	8.26304	9.99993	8.26312	11.73689	10.00007	11.73096	57
4	8.26988	9.99993	8.26996	11.73004	10.00007	11.73012	56
5	8.27661	9.99992	8.27669	11.72331	10.00008	11.72339	55
6	8.28324	9.99992	8.28332	11.71668	10.00008	11.71676	54
7	8.28977	9.99992	8.28986	11.71014	10.00008	11.71023	53
8	8.29621	9.99992	8.29626	11.70371	10.00009	11.70379	52
9	8.30255	9.99991	8.30263	11.69737	10.00009	11.69745	51
10	8.30879	9.99991	8.30888	11.69112	10.00009	11.69121	50
11	8.31495	9.99991	8.31505	11.68495	10.00009	11.68505	49
12	8.32103	9.99991	8.32112	11.67888	10.00010	11.67897	48
13	8.32702	9.99990	8.32711	11.67289	10.00010	11.67298	47
14	8.33292	9.99990	8.33303	11.66698	10.00010	11.66708	46
15	8.33875	9.99990	8.33886	11.66114	10.00010	11.66125	45
16	8.34450	9.99989	8.34461	11.65539	10.00011	11.65550	44
17	8.35018	9.99989	8.35029	11.64971	10.00011	11.64982	43
18	8.35578	9.99989	8.35590	11.64411	10.00011	11.64422	42
19	8.36132	9.99989	8.36143	11.63857	10.00012	11.63869	41
20	8.36678	9.99988	8.36689	11.63311	10.00012	11.63322	40
21	8.37217	9.99988	8.37229	11.62771	10.00012	11.62783	39
22	8.37750	9.99988	8.37762	11.62238	10.00012	11.62250	38
23	8.38276	9.99987	8.38289	11.61711	10.00013	11.61724	37
24	8.38796	9.99987	8.38809	11.61191	10.00013	11.61204	36
25	8.39310	9.99987	8.39323	11.60677	10.00013	11.60690	35
26	8.39818	9.99986	8.39832	11.60169	10.00014	11.60182	34
27	8.40320	9.99986	8.40334	11.59666	10.00014	11.59680	33
28	8.40816	9.99986	8.40830	11.59170	10.00014	11.59184	32
29	8.41307	9.99985	8.41321	11.58679	10.00015	11.58693	31
30	8.41792	9.99985	8.41807	11.58193	10.00015	11.58208	30
		Sine.		Tang.		Secant.	Min.

88 *Degrees.*

Tangents and Secants.

1 *Degree.*

Min.	Sine.		Tang.		Secant.		
30	8.41792	9.99985	8.41807	11.58193	10.00015	11.58208	30
31	8.42272	9.99985	8.42287	11.57713	10.00015	11.57728	29
32	8.42746	9.99984	8.42762	11.57238	10.00016	11.57254	28
33	8.43216	9.99984	8.43232	11.56769	10.00016	11.56784	27
34	8.43680	9.99984	8.43696	11.56304	10.00016	11.56320	26
35	8.44139	9.99983	8.44156	11.55844	10.00017	11.55861	25
36	8.44594	9.99983	8.44611	11.55389	10.00017	11.55406	24
37	8.45044	9.99983	8.45061	11.54939	10.00017	11.54956	23
38	8.45489	9.99982	8.45507	11.54493	10.00018	11.54511	22
39	8.45930	9.99982	8.45948	11.54052	10.00018	11.54070	21
40	8.46366	9.99982	8.46385	11.53615	10.00018	11.53634	20
41	8.46799	9.99981	8.46817	11.53183	10.00019	11.53202	19
42	8.47226	9.99981	8.47245	11.52755	10.00019	11.52774	18
43	8.47650	9.99981	8.47669	11.52331	10.00020	11.32350	17
44	8.48069	9.99980	8.48089	11.51911	10.00020	11.51931	16
45	8.48485	9.99980	8.48505	11.51495	10.00020	11.51515	15
46	8.48896	9.99979	8.48917	11.51083	10.00021	11.51104	14
47	8.49304	9.99979	8.49325	11.50675	10.00021	11.50696	13
48	8.49708	9.99979	8.49729	11.50271	10.00021	11.50292	12
49	8.50108	9.99978	8.50130	11.49870	10.00022	11.49892	11
50	8.50505	9.99978	8.50527	11.49473	10.00022	11.49496	10
51	8.50897	9.99977	8.50920	11.49080	10.00023	11.49103	9
52	8.51287	9.99977	8.51310	11.48690	10.00023	11.48713	8
53	8.51673	9.99977	8.51696	11.48304	10.00024	11.48327	7
54	8.52055	9.99976	8.52079	11.47921	10.00024	11.47945	6
55	8.52434	9.99976	8.52459	11.47541	10.00024	11.47566	5
56	8.52810	9.99975	8.52835	11.47165	10.00025	11.47190	4
57	8.53183	9.99975	8.53208	11.46792	10.00025	11.46817	3
58	8.53552	9.99974	8.53578	11.46422	10.00026	11.46448	2
59	8.53919	9.99974	8.53945	11.46055	10.00026	11.46081	1
60	8.54282	9.99974	8.54308	11.45692	10.00027	11.45718	0
		Sine.		Tang.		Secant.	Min.

88 *Degrees.*

A Table of Artificial Sines,

2 Degrees.

Min.	Sine.		Tang.		Secant.		
0	8.54282	9.99974	8.54308	11.45692	10.00027	11.45718	60
1	8.54642	9.99973	8.54669	11.45331	10.00027	11.45358	59
2	8.55000	9.99973	8.55027	11.44973	10.00027	11.45001	58
3	8.55354	9.99972	8.55382	11.44618	10.00028	11.44646	57
4	8.55705	9.99972	8.55734	11.44266	10.00028	11.44295	56
5	8.56054	9.99971	8.56083	11.43917	10.00029	11.43946	55
6	8.56400	9.99970	8.56429	11.43571	10.00029	11.43600	54
7	8.56743	9.99970	8.56773	11.43227	10.00030	11.43257	53
8	8.57084	9.99970	8.57114	11.42886	10.00030	11.42916	52
9	8.57421	9.99969	8.57452	11.42548	10.00030	11.42579	51
10	8.57757	9.99969	8.57788	11.42212	10.00031	11.42243	50
11	8.58089	9.99968	8.58121	11.41879	10.00032	11.41911	49
12	8.58419	9.99968	8.58451	11.41549	10.00032	11.41581	48
13	8.58747	9.99968	8.58779	11.41221	10.00033	11.41253	47
14	8.59072	9.99967	8.59105	11.40895	10.00033	11.40928	46
15	8.59395	9.99967	8.59428	11.40572	10.00034	11.40605	45
16	8.59715	9.99966	8.59749	11.40251	10.00034	11.40285	44
17	8.60033	9.99966	8.60068	11.39932	10.00035	11.39967	43
18	8.60349	9.99965	8.60384	11.39616	10.00035	11.39651	42
19	8.60662	9.99965	8.60698	11.39302	10.00036	11.39338	41
20	8.60973	9.99964	8.61009	11.38991	10.00036	11.39027	40
21	8.61282	9.99964	8.61319	11.38681	10.00037	11.38718	39
22	8.61589	9.99963	8.61626	11.38374	10.00037	11.38411	38
23	8.61894	9.99962	8.61931	11.38069	10.00038	11.38106	37
24	8.62196	9.99962	8.62234	11.37766	10.00038	11.37804	36
25	8.62497	9.99961	8.62535	11.37465	10.00039	11.37504	35
26	8.62795	9.99960	8.62834	11.37166	10.00039	11.37205	34
27	8.63091	9.99960	8.63131	11.36869	10.00040	11.36909	33
28	8.63385	9.99960	8.63426	11.36574	10.00040	11.36615	32
29	8.63678	9.99960	8.63718	11.36282	10.00041	11.36322	31
30	8.63968	9.99959	8.64009	11.35991	10.00041	11.36032	30
		Sine.		Tang.		Secant.	Min.

87 Degrees.

Tangents, and Secants.

2 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	8.63968	9.99959	8.64009	11.35991	10.00041	11.36032	30
31	8.64256	9.99958	8.64298	11.35702	10.00042	11.35744	29
32	8.64543	9.99958	8.64585	11.35415	10.00043	11.35457	28
33	8.64827	9.99957	8.64870	11.35130	10.00043	11.35173	27
34	8.65110	9.99956	8.65154	11.34846	10.00044	11.34890	26
35	8.65391	9.99956	8.65435	11.34565	10.00044	11.34609	25
36	8.65670	9.99955	8.65715	11.34285	10.00045	11.34330	24
37	8.65948	9.99955	8.65993	11.34007	10.00045	11.34053	23
38	8.66223	9.99954	8.66269	11.33731	10.00046	11.33777	22
39	8.66497	9.99954	8.66543	11.33457	10.00047	11.33503	21
40	8.66769	9.99953	8.66816	11.33184	10.00047	11.33231	20
41	8.67039	9.99952	8.67087	11.32913	10.00048	11.32961	19
42	8.67308	9.99952	8.67356	11.32644	10.00048	11.32692	18
43	8.67575	9.99951	8.67624	11.32376	10.00049	11.32425	17
44	8.67841	9.99951	8.67890	11.32110	10.00049	11.32160	16
45	8.68104	9.99950	8.68154	11.31846	10.00050	11.31896	15
46	8.68367	9.99949	8.68417	11.31583	10.00051	11.31634	14
47	8.68627	9.99949	8.68678	11.31322	10.00051	11.31373	13
48	8.68886	9.99948	8.68938	11.31062	10.00052	11.31114	12
49	8.69144	9.99948	8.69160	11.30804	10.00053	11.30857	11
50	8.69400	9.99947	8.69453	11.30547	10.00053	11.30600	10
51	8.69654	9.99946	8.69708	11.30292	10.00054	11.30346	9
52	8.69907	9.99946	8.69962	11.30038	10.00054	11.30093	8
53	8.70159	9.99945	8.70214	11.29786	10.00055	11.29841	7
54	8.70409	9.99944	8.70465	11.29535	10.00056	11.29591	6
55	8.70658	9.99944	8.70714	11.29286	10.00056	11.29342	5
56	8.70905	9.99943	8.70962	11.29038	10.00057	11.29095	4
57	8.71151	9.99942	8.71208	11.28792	10.00058	11.28849	3
58	8.71395	9.99942	8.71453	11.28547	10.00058	11.28605	2
59	8.71638	9.99941	8.71697	11.28303	10.00059	11.28362	1
60	8.71880	9.99940	8.71940	11.28060	10.00060	11.28120	0
		Sine.		Tang.		Secant.	Min.

87 *Degrees.*

A Table of Artificial Sines,

3 Degrees.

Min.	Sine.		Tang.		Secant.		
0	8.71880	9.99940	8.71940	11.28060	10.00060	11.28120	60
1	8.72120	9.99940	8.72181	11.27819	10.00060	11.27880	59
2	8.72360	9.99939	8.72420	11.27580	10.00061	11.27641	58
3	8.72597	9.99938	8.72659	11.27341	10.00062	11.27403	57
4	8.72834	9.99938	8.72896	11.27104	10.00062	11.27166	56
5	8.73069	9.99937	8.73132	11.26868	10.00063	11.26931	55
6	8.73303	9.99936	8.73366	11.26634	10.00064	11.26697	54
7	8.73535	9.99936	8.73600	11.26400	10.00064	11.26465	53
8	8.73767	9.99935	8.73832	11.26168	10.10065	11.26233	52
9	8.7399	9.99934	8.74063	11.25937	10.00066	11.26003	51
10	8.74226	9.99934	8.74292	11.25708	10.00066	11.25774	50
11	8.74454	9.99933	8.74521	11.25479	10.00067	11.25546	49
12	8.74689	9.99932	8.74748	11.25252	10.00068	11.25320	48
13	8.74906	9.99932	8.74974	11.25026	10.00069	11.25095	47
14	8.75130	9.99931	8.75199	11.24801	10.00069	11.24870	46
15	8.75353	9.99930	8.75423	11.24577	10.00070	11.24647	45
16	8.75575	9.99929	8.75645	11.24355	10.00071	11.24425	44
17	8.75796	9.99929	8.75867	11.24133	10.00071	11.24205	43
18	8.76015	9.99928	8.76087	11.23913	10.00072	11.23985	42
19	8.76234	9.99927	8.76307	11.23694	10.00073	11.23766	41
20	8.76451	9.99927	8.76525	11.23475	10.00074	11.23549	40
21	8.76668	9.99926	8.76742	11.23258	10.00074	11.23333	39
22	8.76883	9.99925	8.76958	11.23042	10 00075	11.23117	38
23	8.77097	9.99924	8.77173	11.22827	10.00076	11.22903	37
24	8.77310	9.99924	8.77387	11.22613	10.00077	11.22690	36
25	8.77522	9.99923	8.77600	11.22401	10.00077	11.22478	35
26	8.77733	9.99922	8.77811	11.22189	10.00078	11.22267	34
27	8.77943	9.99921	8.78022	11.21978	10.00079	11.22057	33
28	5.78152	9.99921	8.78232	11.21768	10.00080	11.21848	32
29	8.78361	9.99920	8.78441	11.21559	10.00080	11.21640	31
30	8.78568	9.99919	8.78649	11.21351	10.00081	11.21433	30
		Sine.		Tang.		Secant.	Min.

86 Degrees.

Tangents, and Secants.

3 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	8.78508	9.99919	8.78649	11.21351	10.00081	11.21433	30
31	8.78774	9.99918	8.78855	11.21145	10.00082	11.21226	29
32	8.78979	9.99917	8.79061	11.20939	10.00083	11.21021	28
33	8.79183	9.99917	8.79266	11.20734	10.00083	11.20817	27
34	8.79386	9.99916	8.79470	11.20530	10.00084	11.20614	26
35	8.79588	9.99915	8.79673	11.20327	10.00085	11.20412	25
36	8.79789	9.99914	8.79875	11.20125	10.00086	11.20211	24
37	8.79990	9.99913	8.80076	11.19924	10.00087	11.20010	23
38	8.80189	9.99913	8.80277	11.19724	10.00087	11.19811	22
39	8.80388	9.99912	8.80476	11.19524	10.00088	11.19612	21
40	8.80585	9.99911	8.80674	11.19326	10.00089	11.19415	20
41	8.80782	9.99910	8.80872	11.19128	10.00090	11.19218	19
42	8.80978	9.99909	8.81068	11.18932	10.00091	11.19022	18
43	8.81173	9.99909	8.81264	11.18736	10.00091	11.18827	17
44	8.81367	9.99908	8.81459	11.18541	10.00092	11.18633	16
45	8.81560	9.99907	8.81653	11.18347	10.00093	11.18440	15
46	8.81752	9.99906	8.81846	11.18154	10.00094	11.18248	14
47	8.81944	9.99905	8.82038	11.17962	10.00095	11.18056	13
48	8.82134	9.99904	8.82230	11.17770	10.00096	11.17866	12
49	8.82324	9.99904	8.82421	11.17580	10.00096	11.17676	11
50	8.82513	9.99903	8.82610	11.17390	10.00097	11.17487	10
51	8.82701	9.99902	8.82799	11.17201	10.00098	11.17299	9
52	8.82888	9.99901	8.82987	11.17013	10.00099	21.17112	8
53	8.83075	9.99900	8.83175	11.16825	10.00100	11.16925	7
54	8.83261	9.99899	8.83361	11.16639	10.00101	11.16739	6
55	8.83446	9.99898	8.83547	11.16453	10.00102	11.16554	5
56	8.83630	9.99898	8.83732	11.16268	10.00102	11.16370	4
57	8.83813	9.99897	8.83916	11.16084	10.00103	11.16187	3
58	8.83996	9.99896	8.84100	11.15900	10.00104	11.16004	2
59	8.84177	9.99895	8.84282	11.15718	10.00105	11.15823	1
60	8.84358	9.99894	8.84464	11.15536	10.00106	11.15642	0
		Sine.		Tang.		Secant.	Min.

86 *Degrees.*

A Table of Artificial Sines,

4 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	8.84358	9.99894	8.84464	11.15536	10.00106	11.15642	60
1	8.84539	9.99893	8.84646	11.15355	10.00107	11.15461	59
2	8.84718	9.99892	8.84826	11.15174	10.00108	11.15282	58
3	8.84897	9.99891	8.85006	11.14994	10.00109	11.15103	57
4	8.85075	9.99891	8.85185	11.14815	10.00110	11.14925	56
5	8.85252	9.99890	8.85363	11.14637	10.00110	11.14748	55
6	8.85429	9.99889	8.85540	11.14460	10.00111	11.14571	54
7	8.85609	9.99888	8.85717	11.14283	10.00112	11.14395	53
8	8.85780	9.99887	8.85893	11.14107	10.00113	11.14220	52
9	8.85995	9.99886	8.86069	11.13931	10.00114	11.14055	51
10	8.86128	9.99885	8.86243	11.13757	10.00115	11.13872	50
11	8.86301	9.99884	8.86417	11.13583	10.00116	11.13699	49
12	8.86474	9.99883	8.86591	11.13409	10.00117	11.13526	48
13	8.86645	9.99882	8.86763	11.13237	10.00118	11.13355	47
14	8.86817	9.99881	8.86935	11.13065	10.00119	11.13184	46
15	8.86987	9.99880	8.87106	11.12894	10.00120	11.13013	45
16	8.87157	9.99880	8.87277	11.12723	10.00121	11.12844	44
17	8.87326	9.99879	8.87447	11.12553	10.00122	11.12675	43
18	8.87494	9.99878	8.87616	11.12384	10.00122	11.12506	42
19	8.87662	9.99877	8.87785	11.12215	10.00123	11.12339	41
20	8.87829	9.99876	8.87953	11.12047	10.00124	11.12172	40
21	8.87995	9.99875	8.88120	11.11880	10.00125	11.12005	39
22	8.88161	9.99874	8.88287	11.11713	10.00126	11.11839	38
23	8.88326	9.99873	8.88453	11.11547	10.00127	11.11674	37
24	8.88490	9.99872	8.88619	11.11382	10.00128	11.11510	36
25	8.88654	9.99871	8.88783	11.11217	10.00129	11.11346	35
26	8.88817	9.99870	8.88948	11.11052	10.00130	11.11183	34
27	8.88980	9.99869	8.89111	11.10889	10.00131	11.11020	33
28	8.89142	9.99868	8.89274	11.10726	10.00132	11.10858	32
29	8.89304	9.99867	8.89437	11.10563	10.00133	11.10697	31
30	8.89464	9.99866	8.89598	11.10402	10.00134	11.10536	30
		Sine.		Tang.		Secant.	Min.

85 *Degrees.*

Tangents, and Secants.

4 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	8.89464	9.99866	8.89598	11.10402	10.00134	11.10536	30
31	8.89625	9.99865	8.89766	11.10240	10.00135	11.10375	29
32	8.89784	9.99864	8.89920	11.10080	10.00136	11.10216	28
33	8.89943	9.99863	8.90080	11.09920	10.00137	11.10057	27
34	8.90102	9.99862	8.90240	11.09760	10.00138	11.09898	26
35	8.90260	9.99891	8.90399	11.09601	10.00139	11.09740	25
36	8.90417	9.99860	8.90557	11.09443	10.00140	11.09583	24
37	8.90574	9.99859	8.90715	11.09285	10.00141	11.09426	23
38	8.90730	9.99858	8.90872	11.09128	10.00142	11.09270	22
39	8.90885	9.99857	8.91029	11.08972	10.00143	11.09115	21
40	8.91040	9.99856	8.91185	11.08815	10.00144	11.08960	20
41	8.91195	9.99855	8.91340	11.08660	10.00145	11.08805	19
42	8.91349	9.99854	8.91495	11.08505	10.00146	11.08651	18
43	8.91502	9.99853	8.91650	11.08351	10.00147	11.08498	17
44	8.91655	9.99852	8.91803	11.08197	10.00148	11.08345	16
45	8.91807	9.99851	8.91957	11.08043	10.00149	11.08193	15
46	8.91959	9.99850	8.92110	11.07890	10.00151	11.08041	14
47	8.92110	9.99849	8.92262	11.07738	10.00152	11.07890	13
48	8.92261	9.99847	8.92414	11.07586	10.00153	11.07739	12
49	8.92411	9.99846	8.92565	11.07435	10.00154	11.07589	11
50	8.92561	9.99845	8.92716	11.07285	10.00155	11.07439	10
51	8.92710	9.99844	8.92866	11.07134	10.00156	11.07290	9
52	8.92859	9.99843	8.93016	11.06985	10.00157	11.07141	8
53	8.93007	9.99842	8.93165	11.06835	10.00158	11.06993	7
54	8.93154	9.99841	8.93313	11.06687	10.00159	11.06846	6
55	8.93302	9.99840	8.93462	11.06538	10.00160	11.06699	5
56	8.93448	9.99839	8.93609	11.06391	10.00161	11.06552	4
57	8.93594	9.99838	8.93757	11.06244	10.00162	11.06406	3
58	8.93740	9.99837	8.93903	11.06097	10.00163	11.06260	2
59	8.93885	9.99836	8.94049	11.05951	10.00165	11.06115	1
60	8.94030	9.99834	8.94195	11.05805	10.00166	11.05970	0
		Sine.		Tang.		Secant.	Min.

85 *Degrees.*

A Table of Artificial Sines,

5 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	8.94030	9.99834	8.94195	11.05805	10.00166	11.05970	60
1	8.94174	9.99833	8.94340	11.05660	10.00167	11.05826	59
2	8.94317	9.99832	8.94485	11.05515	10.00168	11.05683	58
3	8.94461	9.99831	8.94630	11.05371	10.00169	11.05539	57
4	8.94603	9.99830	8.94773	11.05227	10.00170	11.05397	56
5	8.94746	9.99829	8.94917	11.05083	10.00171	11.05254	55
6	8.94887	9.99828	8.95060	11.04949	10.00172	11.05113	54
7	8.95029	9.99827	8.95202	11.0479[illegible]	10.00173	11.0497[illegible]	53
8	8.95170	9.99826	8.95344	11.0465[illegible]	10.00175	11.04830	52
9	8.95310	9.99824	8.95486	11.04514	10.00176	11.04690	51
10	8.95450	9.99823	8.95627	11.04373	10.00177	11.04550	50
11	8.95590	9.99822	8.95767	11.04233	10.00178	11.04411	49
12	8.95728	9.99821	8.95908	11.04093	10.00179	11.04272	48
13	8.95867	9.99820	8.96047	11.0395[illegible]	10.00180	11.04133	47
14	8.96005	9.99819	8.96189	11.0[illegible]813	10.00181	11.03995	46
15	8.96143	9.99817	8.96325	11.03675	10.00183	11.03857	45
16	8.96280	9.99816	8.96464	11.03536	10.00184	11.03720	44
17	8.96417	9.99815	8.96602	11.03398	10.00185	11.03583	43
18	8.96553	9.99814	8.96739	11.03261	10.00186	11.03447	42
19	8.96689	9.99813	8.96877	11.03123	10.00187	11.03311	41
20	8.96825	9.99812	8.97013	11.02987	10.00188	11.03175	40
21	8.96960	9.99810	8.97150	11.02850	10.00190	11.03040	39
22	8.97095	9.99809	8.97286	11.02715	10.00191	11.02905	38
23	8.97229	9.99808	8.97421	11.02579	10.00192	11.02771	37
24	8.97363	9.99807	8.97556	11.02444	10.00193	11.02637	36
25	8.97496	9.99806	8.97691	11.02309	10.00194	11.02504	35
26	8.97629	9.99804	8.97825	11.02175	10.00196	11.02371	34
27	8.97762	9.99803	8.97959	11.02041	10.00197	11.02238	33
28	8.97894	9.99802	8.98092	11.01908	10.00198	11.02106	32
29	8.98026	9.99801	8.98225	11.01775	10.00199	11.01974	31
30	8.98157	9.99800	8.98358	11.01642	10.00200	11.01843	30
		Sine.		Tang.		Secant.	Min.

84 *Degrees.*

Tangents and Secants.

5 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	8.98157	9.99800	8.98358	11.01642	10.00200	11.01843	30
31	8.98288	9.99798	8.98490	11.01510	10.00202	11.01712	29
32	8.98419	9.99797	8.98622	11.01378	10.00203	11.01581	28
33	8.98549	9.99796	8.98753	11.01247	10.00204	11.01451	27
34	8.98679	9.99795	8.98884	11.01116	10.00205	11.01321	26
35	8.98808	9.99794	8.99015	11.00985	10.00207	11.01192	25
36	8.98937	9.99792	8.99145	11.00855	10.00208	11.01063	24
37	8.99066	9.99791	8.99275	11.00725	10.00209	11.00934	23
38	8.99194	9.99790	8.99405	11.00596	10.00210	11.00806	22
39	8.99322	9.99789	8.99534	11.00466	10.00212	11.00678	21
40	8.99450	9.99787	8.99662	11.00338	10.00213	11.00550	20
41	8.99577	9.99786	8.99791	11.00209	10.00214	11.00423	19
42	8.99704	9.99785	8.99919	11.00081	10.00215	11.00296	18
43	8.99830	9.99784	9.00047	10.99954	10.00217	11.00170	17
44	8.99956	9.99782	9.00174	10.99826	10.00218	11.00044	16
45	9.00082	9.99781	9.00301	10.99699	10.00220	10.99918	15
46	9.00207	9.99780	9.00427	10.99573	10.00221	10.99793	14
47	9.00332	9.99778	9.00553	10.99447	10.00222	10.99668	13
48	9.00456	9.99777	9.00679	10.99321	10.00223	10.99544	12
49	9.00581	9.99776	9.00805	10.99195	10.00224	10.99420	11
50	9.00704	9.99775	9.00930	10.99070	10.00216	10.99296	10
51	9.00828	9.99773	9.01055	10.98945	10.00227	10.99172	9
52	9.00951	9.99772	9.01179	10.98821	10.00228	10.99049	8
53	9.01074	9.99771	9.01303	10.98697	10.00229	10.98926	7
54	9.01196	9.99769	9.01427	10.98573	10.00231	10.98804	6
55	9.01318	9.99768	9.01550	10.98450	10.00232	10.98682	5
56	9.01440	9.99767	9.01673	10.98327	10.00233	10.98560	4
57	9.01561	9.99765	9.01796	10.98204	10.00235	10.98439	3
58	9.01682	9.99764	9.01918	10.98082	10.00236	10.98318	2
59	9.01803	9.99763	9.02040	10.97960	10.00237	10.98197	1
60	9.01923	9.99761	9.02162	10.97838	10.00239	10.98077	0
		Sine.		Tang.		Secant.	Min.

84 *Degrees.*

A Table of Artificial Sines,

6 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.01924	9.99761	9.02162	10.97838	10.00239	10.98077	60
1	9.02044	9.99760	9.02283	10.97717	10.00240	10.97957	59
2	9.02163	9.99759	9.02404	10.97596	10.00241	10.97837	58
3	9.02283	9.99757	9.02525	10.97475	10.00243	10.97718	57
4	9.02402	9.99756	9.02646	10.97355	10.00244	10.97598	56
5	9.02520	9.99755	9.02766	10.97235	10.00245	10.97480	55
6	9.02639	9.99753	9.02885	10.97115	10.00247	10.97361	54
7	9.02757	9.99752	9.03005	10.96995	10.00248	10.97243	53
8	9.02874	9.99751	9.03124	10.96876	10.00249	10.97126	52
9	9.02992	9.99749	9.03243	10.96758	10.00251	10.97008	51
10	9.03109	9.99748	9.03361	10.96639	10.00252	10.96891	50
11	9.03226	9.99747	9.03479	10.96521	10.00253	10.96774	49
12	9.03342	9.99745	9.03597	10.96403	10.00255	10.96658	48
13	9.03458	9.99744	9.03714	10.96286	10.00256	10.96542	47
14	9.03574	9.99743	9.03832	10.96168	10.00258	10.96426	46
15	9.03690	9.99741	9.03949	10.96052	10.00259	10.96310	45
16	9.03805	9.99740	9.04065	10.95935	10.00260	10.96195	44
17	9.03920	9.99738	9.04181	10.95819	10.00262	10.96080	43
18	9.04034	9.99737	9.04297	10.95703	10.00263	10.95966	42
19	9.04149	9.99736	9.04413	10.95587	10.00265	10.95852	41
20	9.04263	9.99734	9.04528	10.95472	10.00266	10.95738	40
21	9.04376	9.99733	9.04643	10.95357	10.00267	10.95624	39
22	9.04490	9.99731	9.04758	10.95242	10.00269	10.95511	38
23	9.04603	9.99730	9.04873	10.95127	10.00270	10.95397	37
24	9.047[illegible]5	9.99729	9.04987	10.95013	10.00272	10.95285	36
25	9.04828	9.99727	9.05101	10.94899	10.00273	10.95172	35
26	9.04940	9.99726	9.05214	10.94786	10.00274	10.95060	34
27	9.05052	9.99724	9.05328	10.94672	10.00276	10.94948	33
28	9.05164	9.99723	9.05441	10.94559	10.00277	10.94837	32
29	9.05275	9.99721	9.05554	10.94447	10.00279	10.94725	31
30	9.05386	9.99720	9.05666	10.94334	10.00280	10.94614	30
		Sine.		Tang.		Secant.	Min.

83 *Degrees.*

Tangents, and Secants.

6 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.05386	9.99720	9.05666	10.94334	10.00280	10.94614	30
31	9.05497	9.99719	9.05778	10.94222	10.00282	10.94503	29
32	9.05607	9.99717	9.05890	10.94110	10.00283	10.94393	28
33	9.05717	9.99716	9.06002	10.93998	10.00284	10.94284	27
34	9.05827	9.99714	9.06113	10.93887	10.00286	10.94173	26
35	9.05937	9.99713	9.06224	10.93776	10.00287	10.94063	25
36	9.06046	9.99711	9.06335	10.93665	10.00289	10.93954	24
37	9.06155	9.99710	9.06445	10.93555	10.00290	10.93845	23
38	9.06264	9.99708	9.06556	10.93444	10.00292	10.93736	22
39	9.06372	9.99707	9.06666	10.93335	10.00293	10.93628	21
40	9.06481	9.99705	9.06775	10.93225	10.00295	10.93519	20
41	9.06589	9.99704	9.06885	10.93115	10.00296	10.93412	19
42	9.06696	9.99702	9.06994	10.93006	10.00298	10.93304	18
43	9.06804	9.99701	9.07103	10.92897	10.00299	10.93196	17
44	9.06911	9.99699	9.07211	10.92789	10.00301	10.93089	16
45	9.07018	9.99698	9.07320	10.92680	10.00302	10.92982	15
46	9.07124	9.99696	9.07428	10.92572	10.00304	10.92876	14
47	9.07231	9.99695	9.07536	10.92464	10.00305	10.92769	13
48	9.07337	9.99693	9.07643	10.92357	10.00307	10.92663	12
49	9.07442	9.99692	9.07751	10.92245	10.00308	10.92558	11
50	9.07548	9.99690	9.07858	10.92142	10.00310	10.92452	10
51	9.07653	9.99689	9.07964	10.92036	10.00311	10.92347	9
52	9.07758	9.99687	9.08071	10.91929	10.00313	10.92242	8
53	9.07863	9.99686	9.08177	10.91823	10.00314	10.92137	7
54	9.07968	9.99684	9.08283	10.91717	10.00316	10.92032	6
55	9.08072	9.99683	9.08389	10.91611	10.00317	10.91928	5
56	9.08176	9.99681	9.08495	10.91505	10.00319	10.91824	4
57	9.08280	9.99680	9.08600	10.91400	10.00320	10.91720	3
58	9.08383	9.99678	9.08705	10.91295	10.00322	10.91617	2
59	9.08486	9.99677	9.08810	10.91190	10.00323	10.91514	1
60	9.08589	9.99675	9.08914	10.91086	10.00325	10.91411	0
		Sine.		Tang.		Secant.	Min.

83 *Degrees.*

A Table of Artificial Sines,

6 Degrees.

Min.	Sine.		Tang.		Secant.		
0	9.01924	9.99761	9.02162	10.97838	10.00239	10.98077	60
1	9.02044	9.99760	9.02283	10.97717	10.00240	10.97957	59
2	9.02163	9.99759	9.02404	10.97596	10.00241	10.97837	58
3	9.02283	9.99757	9.02525	10.97475	10.00243	10.97718	57
4	9.02402	9.99756	9.02646	10.97355	10.00244	10.97598	56
5	9.02520	9.99755	9.02766	10.97235	10.00245	10.97480	55
6	9.02639	9.99753	9.02885	10.97115	10.00247	10.97361	54
7	9.02757	9.99752	9.03005	10.96995	10.00248	10.97243	53
8	9.02874	9.99751	9.03124	10.96876	10.00249	10.97126	52
9	9.02992	9.99749	9.03243	10.96758	10.00251	10.97008	51
10	9.03109	9.99748	9.03361	10.96639	10.00252	10.96891	50
11	9.03226	9.99747	9.03479	10.96521	10.00253	10.96774	49
12	9.03342	9.99745	9.03597	10.96403	10.00255	10.96658	48
13	9.03458	9.99744	9.03714	10.96286	10.00256	10.96542	47
14	9.03574	9.99743	9.03832	10.96168	10.00258	10.96426	46
15	9.03690	9.99741	9.03949	10.96052	10.00259	10.96310	45
16	9.03805	9.99740	9.04065	10.95935	10.00260	10.96195	44
17	9.03920	9.99738	9.04181	10.95819	10.00262	10.96080	43
18	9.04034	9.99737	9.04297	10.95703	10.00263	10.95966	42
19	9.04149	9.99736	9.04413	10.95587	10.00265	10.95852	41
20	9.04263	9.99734	9.04528	10.95472	10.00260	10.95738	40
21	9.04376	9.99733	9.04643	10.95357	10.00267	10.95624	39
22	9.04490	9.99731	9.04758	10.95242	10.00269	10.95511	38
23	9.04603	9.99730	9.04873	10.95127	10.00270	10.95397	37
24	9.047[illegible]5	9.99729	9.04987	10.95013	10.00272	10.95285	36
25	9.04828	9.99727	9.05101	10.94899	10.00273	10.95172	35
26	9.04940	9.99726	9.05214	10.94786	10.00274	10.95060	34
27	9.05052	9.99724	9.05328	10.94672	10.00276	10.94948	33
28	9.05164	9.99723	9.05441	10.94559	10.00277	10.94837	32
29	9.05275	9.99721	9.05554	10.94447	10.00279	10.94725	31
30	9.05386	9.99720	9.05666	10.94334	10.00280	10.94614	30
		Sine.		Tang.		Secant.	Min.

83 Degrees.

Tangents, and Secants.

6 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.05386	9.99720	9.05666	10.94334	10.00280	10.94614	30
31	9.05497	9.99719	9.05778	10.94222	10.00282	10.94503	29
32	9.05607	9.99717	9.05890	10.94110	10.00283	10.94393	28
33	9.05717	9.99716	9.06002	10.93998	10.00284	10.94284	27
34	9.05827	9.99714	9.06113	10.93887	10.00286	10.94173	26
35	9.05937	9.99713	9.06224	10.93776	10.00287	10.94063	25
36	9.06046	9.99711	9.06335	10.93665	10.00289	10.93954	24
37	9.06155	9.99710	9.06445	10.93555	10.00290	10.93845	23
38	9.06264	9.99708	9.06556	10.93444	10.00292	10.93736	22
39	9.06372	9.99707	9.06666	10.93335	10.00293	10.93628	21
40	9.06481	9.99705	9.06775	10.93225	10.00295	10.93519	20
41	9.06589	9.99704	9.06885	10.93115	10.00296	10.93412	19
42	9.06696	9.99702	9.06994	10.93006	10.00298	10.93304	18
43	9.06804	9.99701	9.07103	10.92897	10.00299	10.93196	17
44	9.06911	9.99699	9.07211	10.92789	10.00301	10.93089	16
45	9.07018	9.99698	9.07320	10.92680	10.00302	10.92982	15
46	9.07124	9.99696	9.07428	10.92572	10.00304	10.92876	14
47	9.07231	9.99695	9.07536	10.92464	10.00305	10.92769	13
48	9.07337	9.99693	9.07643	10.92357	10.00307	10.92663	12
49	9.07442	9.99692	9.07751	10.92245	10.00308	10.92558	11
50	9.07548	9.99690	9.07858	10.92142	10.00310	10.92452	10
51	9.07653	9.99689	9.07964	10.92036	10.00311	10.92347	9
52	9.07758	9.99687	9.08071	10.9[illegible]929	10.00313	10.92242	8
53	9.07863	9.99686	9.08177	10.91823	10.00314	10.92137	7
54	9.07968	9.99684	9.08283	10.91717	10.00316	10.92032	6
55	9.08072	9.99683	9.08389	10.91611	10.00317	10.91928	5
56	9.08176	9.99681	9.08495	10.91505	10.00319	10.91824	4
57	9.08280	9.99680	9.08600	10.91400	10.00320	10.91720	3
58	9.08383	9.99678	9.08705	10.91295	10.00322	10.91617	2
59	9.08486	9.99677	9.08810	10.91190	10.00323	10.91514	1
60	9.08589	9.99675	9.08914	10.91086	10.00325	10.91411	0
		Sine.		Tang.		Secant.	Min.

83 Degrees.

A Table of Artificial Sines,

7 Degrees.

Min.	Sine.		Tang.		Secant.		
0	9.08589	9.99675	9.08914	10.91086	10.00325	10.91411	60
1	9.08692	9.99674	9.09019	10.90981	10.00327	10.91308	59
2	9.08795	9.99672	9.09123	10.90877	10.00328	10.91205	58
3	9.08897	9.99670	9.09227	10.90773	10.00330	10.91103	57
4	9.08999	9.99669	9.09330	10.90670	10.00331	10.91001	56
5	9.09101	9.99667	9.09434	10.90566	10.00333	10.90899	55
6	9.09202	9.99666	9.09537	10.90463	10.00334	10.90798	54
7	9.09304	9.99664	9.09640	10.90360	10.00336	10.90696	53
8	9.09405	9.99663	9.09740	10.90258	10.00338	10.90595	52
9	9.09506	9.99661	9.09845	10.90155	10.00339	10.90494	51
10	9.09606	9.99659	9.09947	10.90053	10.00341	10.90394	50
11	9.09707	9.99658	9.10049	10.89951	10.00342	10.90294	49
12	9.09807	9.99656	9.10150	10.89850	10.00344	10.90193	48
13	9.09907	9.99655	9.10252	10.89748	10.00345	10.90094	47
14	9.10006	9.99653	9.10353	10.89647	10.00347	10.89994	46
15	9.10106	9.99651	9.10454	10.89546	10.00349	10.89894	45
16	9.10205	9.99650	9.10555	10.89445	10.00350	10.89795	44
17	9.10304	9.99648	9.10656	10.89344	10.00352	10.89696	43
18	9.10403	9.99647	9.10756	10.89244	10.00353	10.89598	42
19	9.10501	9.99644	9.10856	10.89144	10.00355	10.89499	41
20	9.10599	9.99643	9.10956	10.89044	10.00357	10.89401	40
21	9.10697	9.99642	9.11056	10.88944	10.00358	10.89303	39
22	9.10795	9.99640	9.11155	10.88845	10.00360	10.89205	38
23	9.10893	9.99638	9.11254	10.88746	10.00362	10.89107	37
24	9.10990	9.99637	9.11353	10.88647	10.00363	10.89010	36
25	9.11087	9.99635	9.11452	10.88548	10.00365	10.88913	35
26	9.11184	9.99634	9.11551	10.88449	10.00367	10.88816	34
27	9.11281	9.99632	9.11649	10.88351	10.00368	10.88719	33
28	9.11377	9.99630	9.11747	10.88253	10.00370	10.88623	32
29	9.11474	9.99629	9.11845	10.88155	10.00372	10.88526	31
30	9.11570	9.99627	9.11943	10.88057	10.00373	10.88430	30
		Sine.		Tang.		Secant.	Min.

82 Degrees.

Tangents, and Secants.

7 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.11570	9.99627	9.11943	10.88057	10.00373	10.88430	30
31	9.11666	9.99625	9.12040	10.87960	10.00375	10.88334	29
32	9.11761	9.99624	9.12138	10.87862	10.00377	10.88239	28
33	9.11857	9.99622	9.12235	10.87765	10.00378	10.88143	27
34	9.11952	9.99620	9.12332	10.87668	10.00380	10.88048	26
35	9.12047	9.99619	9.12428	10.87572	10.00382	10.87953	25
36	9.12142	9.99617	9.12525	10.87475	10.00383	10.87858	24
37	9.12236	9.99615	9.12620	10.87379	10.00385	10.87764	23
38	9.12331	9.99613	9.12717	10.87283	10.00387	10.87669	22
39	9.12425	9.99612	9.12813	10.87187	10.00388	10.87575	21
40	9.12519	9.99610	9.12909	10.87091	10.00390	10.87481	20
41	9.12613	9.99608	9.13004	10.86996	10.00392	10.87388	19
42	9.12706	9.99607	9.13099	10.86901	10.00393	10.87295	18
43	9.12799	9.99605	9.13194	10.86806	10.00395	10.87201	17
44	9.12893	9.99603	9.13289	10.86711	10.00397	10.87108	16
45	9.12985	9.99602	9.13384	10.86616	10.00399	10.87015	15
46	9.13078	9.99600	9.13478	10.86522	10.00400	10.86922	14
47	9.13171	9.99598	9.13573	10.86427	10.00402	10.86829	13
48	9.13263	9.99596	9.13667	10.86333	10.00404	10.86737	12
49	9.13355	9.99595	9.13761	10.86240	10.00405	10.86645	11
50	9.13447	9.99593	9.13854	10.86146	10.00407	10.86553	10
51	9.13539	9.99591	9.13948	10.86052	10.00409	10.86461	9
52	9.13630	9.99589	9.14041	10.85959	10.00411	10.86370	8
53	9.13722	9.99588	9.14134	10.85866	10.00412	10.86278	7
54	9.13813	9.99586	9.14227	10.85773	10.00414	10.86187	6
55	9.13904	9.99584	9.14320	10.85680	10.00416	10.86096	5
56	9.13994	9.99582	9.14412	10.85588	10.00418	10.86006	4
57	9.14085	9.99581	9.14504	10.85496	10.00419	10.85915	3
58	9.14175	9.99579	9.14597	10.85403	10.00421	10.85825	2
59	9.14266	9.99577	9.14689	10.85312	10.00423	10.85734	1
60	9.14356	9.99575	9.14780	10.85220	10.00425	10.85645	0
		Sine.		Tang.		Secant.	Min.

82 *Degrees.*

A Table of Artificial Sines,

8 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.14356	9.99575	9.14780	10.85220	10.00425	10.85645	60
1	9.14445	9.99574	9.14872	10.85128	10.00427	10.85555	59
2	9.14535	9.99572	9.14963	10.85037	10.00428	10.85465	58
3	9.14624	9.99570	9.15054	10.84946	10.00430	10.85376	57
4	9.14714	9.99568	9.15145	10.84855	10.00432	10.85286	56
5	9.14803	9.99566	9.15236	10.84764	10.00434	10.85197	55
6	9.14892	9.99565	9.15327	10.84673	10.00435	10.85109	54
7	9.14980	9.99563	9.15417	10.84583	10.00437	10.85020	53
8	9.15069	9.99561	9.15508	10.84492	10.00439	10.84931	52
9	9.15157	9.99559	9.15598	10.84402	10.00441	10.84843	51
10	9.15245	9.99557	9.15689	10.84312	10.00443	10.84755	50
11	9.15333	9.99556	9.15778	10.84223	10.00445	10.84667	49
12	9.15421	9.99554	9.15867	10.84133	10.00446	10.84579	48
13	9.15508	9.99552	9.15957	10.84044	10.00448	10.84492	47
14	9.15596	9.99550	9.16046	10.83954	10.00450	10.84404	46
15	9.15683	9.99548	4.16135	10.83865	10.00452	10.84317	45
16	9.15770	9.99546	9.16224	10.83776	10.00454	10.84230	44
17	9.15857	9.99545	9.16312	10.83688	10.00455	10.84143	43
18	9.15944	9.99543	9.16401	10.83599	10.00457	10.84057	42
19	9.16030	9.99541	9.16489	10.83511	10.00459	10.83970	41
20	9.16116	9.99539	9.16577	10.83423	10.00461	10.83884	40
21	9.16203	9.99537	9.16665	10.83335	10.00463	10.83797	39
22	9.16289	9.99535	9.16753	10.83247	10.00465	10.83712	38
23	9.16374	9.99533	9.16850	10.83159	10.00467	10.83626	37
24	9.16460	9.99532	9.16928	10.83072	10.00468	10.83540	36
25	9.16545	9.99530	9.17016	10.82984	10.00470	10.83455	35
26	9.16631	9.99528	9.17103	10.82897	10.00472	10.83369	34
27	9.16716	9.99526	9.17190	10.82810	10.00474	10.83284	33
28	9.16801	9.99524	9.17277	10.82723	10.00476	10.83199	32
29	9.16886	9.99522	9.17363	10.82637	10.00478	10.83114	31
30	9.16970	9.99520	9.17450	10.82550	10.00480	10.83030	30
		Sine.		Tang.		Secant.	Min.

81 *Degrees.*

Tangents, and Secants.

8 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.16970	9.99520	9.17450	10.82550	10.00480	10.83030	30
31	9.17055	9.99518	9.17536	10.82464	10.00482	10.82945	29
32	9.17139	9.99517	9.17622	10.82378	10.00484	10.82861	28
33	9.17223	9.99515	9.17708	10.82292	10.00485	10.82777	27
34	9.17307	9.99513	9.17794	10.82206	10.00487	10.82693	26
35	9.17391	9.99511	9.17880	10.82120	10.00489	10.82609	25
36	9.17474	9.99509	9.17966	10.82035	10.00491	10.82526	24
37	9.17558	9.99507	9.18051	10.81949	10.00493	10.82442	23
38	9.17641	9.99505	9.18136	10.81864	10.00495	10.82359	22
39	9.17724	9.99503	9.18221	10.81779	10.00497	10.82276	21
40	9.17807	9.99501	9.18306	10.81694	10.00499	10.82193	20
41	8.17890	9.99499	9.18391	10.81609	10.00501	10.82111	19
42	9.17973	9.99497	9.18475	10.41525	10.00503	10.82027	18
43	9.18055	9.99496	9.18560	10.81440	10.00505	10.81949	17
44	9.18137	9.99494	9.18644	10.81356	10.00507	10.81863	16
45	9.18220	9.99492	9.18728	10.81272	10.00508	10.81780	15
46	9.18302	9.99490	9.18812	10.81188	10.00510	10.81698	14
47	9.18383	9.99488	9.18896	10.81104	10.00512	10.81617	13
48	9.18465	9.99486	9.18979	10.81021	10.00514	10.81535	12
49	9.18547	9.99484	9.19063	10.80937	10.00516	10.81453	11
50	9.18628	9.99482	9.19146	10.80854	10.00518	10.81372	10
51	9.18709	9.99480	9.19229	10.80771	10.00520	10.81291	9
52	9.18790	9.99478	9.19312	10.80688	10.00522	10.81210	8
53	9.18871	9.99476	9.19395	10.80605	10.00524	10.81129	7
54	9.18952	9.99474	9.19478	10.80522	10.00526	10.81048	6
55	9.19033	9.99473	9.19561	10.80439	10.00528	10.80968	5
56	9.19113	9.99470	9.19643	10.80357	10.00530	10.80887	4
57	9.19193	9.99468	9.19725	10.80275	10.00532	10.80807	3
58	9.19273	9.99466	9.19807	10.80193	10.00534	10.80727	2
59	9.19353	9.99464	9.19889	10.80111	10.00536	10.80647	1
60	9.19433	9.99462	9.19971	10.80026	10.00538	10.80567	0
		Sine.		Tang.		Secant.	Min.

81 *Degrees.*

A Table of Artificial Sines,

9 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.19433	9.99462	9.19971	10.80029	10.00538	10.80567	60
1	9.19513	9.99460	9.20053	10.79947	10.00540	10.80488	59
2	9.19593	9.99458	9.20135	10.79866	10.00542	10.80408	58
3	9.19672	9.99456	9.20216	10.79784	10.00544	10.80328	57
4	9.19751	9.99454	9.20297	10.79703	10.00546	10.80249	56
5	9.19830	9.99452	9.20378	10.79022	10.00548	10.80170	55
6	9.19909	9.99450	9.20459	10.79541	10.00550	10.80091	54
7	9.19988	9.99448	9.20540	10.79460	10.00552	10.80012	53
8	9.20067	9.99446	9.20621	10.79379	10.00554	10.79933	52
9	9.20145	9.99444	9.20701	10.79299	10.00556	10.79855	51
10	9.20223	9.99442	9.20782	10.79218	10.00558	10.79777	50
11	9.20302	9.99440	9.20862	10.79138	10.00560	10.79698	49
12	9.20380	9.99438	9.20942	10.79058	10.00562	10.79620	48
13	9.20458	9.99436	9.21022	10.78978	10.00564	10.79542	47
14	9.20535	9.99434	9.21102	10.78898	10.00566	10.79465	46
15	9.20613	9.99432	9.21182	10.78819	10.00568	10.79387	45
16	9.20691	9.99430	9.21261	10.78739	10.00571	10.79309	44
17	9.20768	9.99427	9.21341	10.78660	10.00572	10.79232	43
18	9.20845	9.99425	9.21420	10.78580	10.00575	10.79155	42
19	9.20922	9.9942[illegible]	9.21499	10.78501	10.00577	10.79078	41
20	9.20999	9.99421	9.21578	10.78422	10.00579	10.79001	40
21	9.21076	9.99419	9.21657	10.78343	10.00581	10.78924	39
22	9.21153	9.99417	9.21736	10.78264	10.00583	10.78847	38
23	9.21229	9.99415	9.21814	10.78186	10.00585	10.78771	37
24	9.21300	9.99413	9.21893	10.78107	10.00587	10.78695	36
25	9.21382	9.99411	9.21971	10.78029	10.00589	10.78618	35
26	9.21458	9.99409	9.22049	10.77951	10.00591	10.78542	34
27	9.21534	9.99407	9.22127	10.77873	10.00593	10.78466	33
28	9.21610	9.99405	9.22205	10.77795	10.00596	10.78390	32
29	9.21685	9.99402	9.22283	10.77717	10.00598	10.78315	31
30	9.21761	9.99400	9.22361	10.77639	10.00600	10.78239	30
		Sine.		Tang.		Secant.	Min.

80 *Degrees.*

Tangents, and Secants.

9 *Degrees*.

Min.	Sine.		Tang.		Secant.		
30	9.21761	9.99400	9.22361	10.77639	10.00600	10.78239	30
31	9.21836	9.99398	9.22438	10.77562	10.00602	10.78164	29
32	9.21912	9.99396	9.22516	10.77484	10.00604	10.78088	28
33	9.21987	9.99394	9.22593	10.77407	10.00606	10.78013	27
34	9.22062	9.99392	9.22670	10.77330	10.00608	10.77938	26
35	9.22137	9.99390	9.22747	10.77253	10.00610	10.77863	25
36	9.22212	9.99388	9.22824	10.77176	10.00613	10.77789	24
37	9.22286	9.99385	9.22901	10.77099	10.00615	10.77714	23
38	9.22361	9.99382	9.22977	10.77023	10.00617	10.77639	22
39	9.22435	9.99381	9.23054	10.76946	10.00619	10.77565	21
40	9.22509	9.99379	9.23131	10.76870	10.00621	10.77491	20
41	9.22583	9.99377	9.23207	10.76794	10.00623	10.77417	19
42	9.22657	9.99375	9.23283	10.76717	10.00625	10.77343	18
43	9.22731	9.99373	9.23359	10.76641	10.00628	10.77269	17
44	9.22805	9.99370	9.23435	10.76566	10.00630	10.77195	16
45	9.22878	9.99368	9.23510	10.76490	10.00632	10.77122	15
46	9.22952	9.99366	9.23586	10.76414	10.00634	10.77048	14
47	9.23025	9.99364	9.23661	10.76339	10.00636	10.76975	13
48	9.23098	9.99362	9.23737	10.76263	10.00638	10.76902	12
49	9.23171	9.99359	9.23812	10.76188	10.00641	10.76829	11
50	9.23244	9.99357	9.23887	10.76113	10.00643	10.76756	10
51	9.23317	9.99355	9.23962	10.76038	10.00645	10.76683	9
52	9.23390	9.99353	9.24037	10.75963	10.00647	10.76610	8
53	9.23463	9.99351	9.24112	10.75888	10.00649	10.76538	7
54	9.23535	9.99348	9.24187	10.75814	10.00652	10.76465	6
55	9.23607	9.99346	9.24261	10.75739	10.00654	10.76393	5
56	9.23680	9.99344	9.24335	10.75665	10.00656	10.76321	4
57	9.23752	9.99342	9.24410	10.75590	10.00658	10.76249	3
58	9.23824	9.99340	9.24484	10.75516	10.00660	10.76177	2
59	9.23895	9.99337	9.24558	10.75442	10.00663	10.76105	1
60	9.23967	9.99335	9.24032	10.75368	10.00665	10.76033	0
		Sine.		Tang.		Secant.	Min.

80 *Degrees*.

A Table of Artificial Sines,

10 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.23967	9.99335	9.24632	10.75368	10.00665	10.76033	60
1	9.24039	9.99333	9.24706	10.75294	10.00667	10.75961	59
2	9.24110	9.99331	9.24779	10.75221	10.00669	10.75890	58
3	9.24181	9.99328	9.24853	10.75147	10.00672	10.75819	57
4	9.24253	9.99326	9.24926	10.75074	10.00674	10.75747	56
5	9.24324	9.99324	9.25000	10.75000	10.00676	10.75676	55
6	9.24395	9.99322	9.25073	10.74927	10.00678	10.75605	54
7	9.24466	9.99320	9.25146	10.74854	10.00681	10.75534	53
8	9.24536	9.99317	9.25219	10.74781	10.00683	10.75464	52
9	9.24607	9.99315	9.25292	10.74708	10.00685	10.75393	51
10	9.24678	9.99313	9.25365	10.74635	10.00687	10.75323	50
11	9.24748	9.99310	9.25437	10.74563	10.00690	10.75252	49
12	9.24818	9.99308	9.25510	10.74490	10.00692	10.75182	48
13	9.24888	9.99306	9.25582	10.74418	10.00694	10.75112	47
14	9.24958	9.99304	9.25655	10.74345	10.00696	10.75042	46
15	9.25028	9.99301	9.25727	10.74273	10.00699	10.74972	45
16	9.25098	9.99299	9.25799	10.74201	10.00701	10.74902	44
17	9.25168	9.99297	9.25871	10.74129	10.00703	10.74832	43
18	9.25237	9.99294	9.25943	10.74057	10.00706	10.74763	42
19	9.25307	9.99292	9.26015	10.73985	10.00708	10.74693	41
20	9.25376	9.99290	9.26086	10.73914	10.00710	10.74624	40
21	9.25445	9.99288	9.26158	10.73842	10.00713	10.74555	39
22	9.25514	9.99285	9.26229	10.73771	10.00715	10.74486	38
23	9.25583	9.99283	9.26301	10.73700	10.00717	10.74417	37
24	9.25652	9.99281	9.26372	10.73628	10.00719	10.74348	36
25	9.25721	9.99278	9.26443	10.73557	10.00722	10.74279	35
26	9.25790	9.99276	9.26514	10.73486	10.00724	10.74210	34
27	9.25858	9.99274	9.26585	10.73415	10.00726	10.74142	33
28	9.25927	9.99271	9.26656	10.73345	10.00729	10.74073	32
29	9.25995	9.99270	9.26726	10.73274	10.00731	10.74005	31
30	9.26063	9.99267	9.26797	10.73203	10.00733	10.73937	30
		Sine.		Tang.		Secant.	Min.

79 *Degrees.*

Tangents, and Secants.

10 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.26063	9.99267	9.26797	10.73203	10.00733	10.73937	30
31	9.26131	9.99264	9.26867	10.73133	10.00736	10.73869	29
32	9.26199	9.99262	9.26938	10.73063	10.00738	10.73801	28
33	9.26267	9.99260	9.27008	10.72992	10.00740	10.73733	27
34	9.26335	9.99257	9.27078	10.72922	10.00743	10.73665	26
35	9.26403	9.99255	9.27148	10.72852	10.00745	10.73597	25
36	9.26470	9.99253	9.27218	10.72782	10.00748	10.73530	24
37	9.26538	9.99250	9.27288	10.72712	10.00750	10.73462	23
38	9.26605	9.99248	9.27357	10.72643	10.00752	10.73395	22
39	9.26672	9.99245	9.27427	10.72573	10.00755	10.73328	21
40	9.26739	9.99243	9.27496	10.72504	10.00757	10.73261	20
41	9.26807	9.99241	9.27566	10.72434	10.00759	10.73194	19
42	9.26873	9.99238	9.27635	10.72365	10.00762	10.73127	18
43	9.26940	9.99236	9.27704	10.72296	10.00764	10.73060	17
44	9.27007	9.99234	9.27773	10.72227	10.00767	10.72993	16
45	9.27074	9.99231	9.27842	10.72158	10.00769	10.72927	15
46	9.27140	9.99229	9.27911	10.72089	10.00771	10.72860	14
47	9.27206	9.99226	9.27980	10.72020	10.00774	10.72794	13
48	9.27273	9.99224	9.28049	10.71951	10.00776	10.72727	12
49	9.27339	9.99221	9.28117	10.71883	10.00779	10.72661	11
50	9.27405	9.99219	9.28186	10.71814	10.00781	10.72595	10
51	9.27471	9.99217	9.28254	10.71746	10.00783	10.72529	9
52	9.27537	9.99214	9.28323	10.71678	10.00786	10.72463	8
53	9.27602	9.99212	9.28391	10.71609	10.00788	10.72398	7
54	9.27668	9.99209	9.28459	10.71541	10.00791	10.72332	6
55	9.27734	9.99207	9.28527	10.71473	10.00793	10.72266	5
56	9.27799	9.99204	9.28595	10.71405	10.00796	10.72201	4
57	9.27864	9.99202	9.28662	10.71338	10.00798	10.72136	3
58	9.27930	9.99200	9.28730	10.71270	10.00800	10.72070	2
59	9.27995	9.99197	9.28798	10.71202	10.00803	10.72005	1
60	9.28060	9.99195	9.28865	10.71135	10.00805	10.71940	0
		Sine.		Tang.		Secant.	Min.

79 *Degrees.*

L

A Table of Artificial Sines,

11 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.28060	9.99195	9.28865	10.71135	10.00805	10.71940	60
1	9.28125	9.99192	9.28933	10.71067	10.00808	10.71875	59
2	9.28190	9.99190	9.29000	10.71000	10.00810	10.71810	58
3	9.28254	9.99187	9.29067	10.70933	10.00813	10.71746	57
4	9.28319	9.99185	9.29134	10.70866	10.00815	10.71681	56
5	9.28384	9.99182	9.29201	10.70799	10.00818	10.71616	55
6	9.28448	9.99180	9.29268	10.70732	10.00820	10.71552	54
7	9.28512	9.99177	9.29335	10.70665	10.00823	10.71488	53
8	9.28577	9.99175	9.29402	10.70598	10.00825	10.71423	52
9	9.28641	9.99172	9.29468	10.70532	10.00828	10.71359	51
10	9.28705	9.99170	9.29535	10.70465	10.00830	10.71295	50
11	9.28769	9.99167	9.29601	10.70399	10.00833	10.71231	49
12	9.28833	9.99165	9.29668	10.70332	10.00835	10.71167	48
13	9.28896	9.99162	9.29734	10.70266	10.00838	10.71104	47
14	9.28960	9.99160	9.29800	10.70200	10.00840	10.71040	46
15	9.29024	9.99157	9.29866	10.70134	10.00843	10.70976	45
16	9.29087	9.99155	9.29932	10.70068	10.00845	10.70913	44
17	9.29150	9.99152	9.29998	10.70002	10.00848	10.70850	43
18	9.29214	9.99150	9.30064	10.69936	10.00850	10.70786	42
19	9.29277	9.99147	9.30130	10.69871	10.00853	10.70723	41
20	9.29340	9.99145	9.30195	10.69805	10.00855	10.70660	40
21	9.29403	9.99142	9.30261	10.69739	10.00858	10.70597	39
22	9.29466	9.99140	9.30326	10.69674	10.00860	10.70534	38
23	9.29529	9.99137	9.30391	10.69609	10.00863	10.70471	37
24	9.29591	9.99135	9.30457	10.69543	10.00865	10.70409	36
25	9.29654	9.99132	9.30522	10.69478	10.00868	10.70346	35
26	9.29716	9.99130	9.30587	10.69413	10.00871	10.70284	34
27	9.29779	9.99127	9.30652	10.69348	10.00873	10.70221	33
28	9.29841	9.99124	9.30717	10.69283	10.00876	10.70159	32
29	9.29903	9.99122	9.30782	10.69218	10.00878	10.70097	31
30	9.29966	9.99119	9.30846	10.69154	10.00881	10.70035	30
		Sine.		Tang.		Secant.	Min.

78 *Degrees.*

Tangents, and Secants.

11 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.29966	9.99119	9.30846	10.69154	10.00881	10.70035	30
31	9.30028	9.99117	9.30911	10.69089	10.00883	10.69972	29
32	9.30090	9.99114	9.30975	10.69025	10.00886	10.69911	28
33	9.30151	9.99112	9.31040	10.68960	10.00889	10.69849	27
34	9.30213	9.99109	9.31104	10.68896	10.00891	10.69787	26
35	9.30275	9.99106	9.31169	10.68832	10.00894	10.69725	25
36	9.30336	9.99104	9.31233	10.68767	10.00896	10.69664	24
37	9.30398	9.99101	9.31297	10.68703	10.00899	10.69602	23
38	9.30459	9.99099	9.31361	10.68639	10.00901	10.69541	22
39	9.30521	9.99096	9.31425	10.68575	10.00904	10.69479	21
40	9.30582	9.99093	9.31489	10.68512	10.00907	10.69418	20
41	9.30643	9.99091	9.31552	10.68448	10.00909	10.69357	19
42	9.30704	9.99088	9.31616	10.68384	10.00912	10.69296	18
43	9.30765	9.99086	9.31680	10.68321	10.00915	10.69235	17
44	9.30826	9.99083	9.31743	10.68257	10.00917	10.69174	16
45	9.30887	9.99080	9.31806	10.68194	10.00920	10.69113	15
46	9.30947	9.99078	9.31870	10.68130	10.00922	10.69053	14
47	9.31008	9.99075	9.31933	10.68067	10.00925	10.68992	13
48	9.31069	9.99072	9.31996	10.68004	10.00928	10.68932	12
49	9.31129	9.99070	9.32059	10.67941	10.00930	10.68871	11
50	9.31189	9.99067	9.32122	10.67878	10.00933	10.68811	10
51	9.31250	9.99064	9.32185	10.67815	10.00936	10.68751	9
52	9.31310	9.99062	9.32248	10.67752	10.00938	10.68690	8
53	9.31370	9.99059	9.32311	10.67689	10.00941	10.68630	7
54	9.31430	9.99057	9.32373	10.67627	10.00944	10.68570	6
55	9.31490	9.99054	9.32436	10.67564	10.00946	10.68510	5
56	9.31550	9.99051	9.32498	10.67502	10.00949	10.68451	4
57	9.31609	9.99049	9.32561	10.67439	10.00952	10.68391	3
58	9.31669	9.99046	9.32623	10.67377	10.00954	10.68331	2
59	9.31728	9.99043	9.32685	10.67315	10.00957	10.68272	1
60	9.31788	9.99040	9.32747	10.67253	10.00960	10.68212	0
		Sine.		Tang.		Secant.	Min.

78 *Degrees.*

A Table of Artificial Sines,

12 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.31788	9.99040	9.32747	10.67253	10.00960	10.68212	60
1	9.31847	9.99038	9.32810	10.67191	10.00962	10.68153	59
2	9.31907	9.99035	9.32872	10.67129	10.00965	10.68093	58
3	9.31966	9.99032	9.32933	10.67067	10.00968	10.68034	57
4	9.32025	9.99030	9.32995	10.67005	10.00970	10.67974	56
5	9.32084	9.99027	9.33057	10.66994	10.00973	10.67916	55
6	9.32143	9.99024	9.33119	10.66881	10.00976	10.67857	54
7	9.32202	9.99022	9.33180	10.66820	10.00978	10.67798	53
8	9.32261	9.99019	9.33242	10.66758	10.00981	10.67739	52
9	9.32319	9.99016	9.33303	10.66697	10.00984	10.67681	51
10	9.32378	9.99013	9.33365	10.66635	10.00987	10.67622	50
11	9.32437	9.99011	9.33426	10.66574	10.00989	10.67563	49
12	9.32495	9.99008	9.33487	10.66513	10.00992	10.67505	48
13	9.32553	9.99005	9.33548	10.66452	10.00995	10.67447	47
14	9.32612	9.99003	9.33609	10.66391	10.00998	10.67388	46
15	9.32670	9.99000	9.33670	10.66330	10.01000	10.67330	45
16	9.32728	9.98997	9.33731	10.66269	10.01003	10.67272	44
17	9.32786	9.98994	9.33792	10.66208	10.01006	10.67214	43
18	9.32844	9.98992	9.33853	10.66147	10.01009	10.67156	42
19	9.32902	9.98989	9.33913	10.66087	10.01011	10.67098	41
20	9.32960	9.98986	9.33974	10.66026	10.01014	10.67040	40
21	9.33018	9.98983	9.34034	10.65966	10.01017	10.66982	39
22	9.33075	9.98980	9.34095	10.65905	10.01020	10.66925	38
23	9.33133	9.98978	9.34155	10.65845	10.01022	10.66867	37
24	9.33190	9.98975	9.34216	10.65785	10.01025	10.66810	36
25	9.33248	9.98972	9.34276	10.65724	10.01028	10.66752	35
26	9.33305	9.98969	9.34336	10.65664	10.01031	10.66695	34
27	9.33362	9.98967	9.34396	10.65604	10.01034	10.66638	33
28	9.33420	9.98964	9.34456	10.65544	10.01036	10.66580	32
29	9.33477	9.98961	9.34516	10.65484	10.01039	10.66523	31
30	9.33534	9.98958	9.34576	10.65425	10.01042	10.66466	30
		Sine.		Tang.		Secant.	Min.

77 *Degrees.*

Tangents, and Secants.

12 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.33534	9.98958	9.34576	10.65425	10.01042	10.66466	30
31	9.33591	9.98955	9.34635	10.65365	10.01045	10.66409	29
32	9.33648	9.98953	9.34695	10.65305	10.01048	10.66353	28
33	9.33704	9.98950	9.34755	10.65246	10.01050	10.66296	27
34	9.33761	9.98947	9.34814	10.65186	10.01053	10.66239	26
35	9.33818	9.98944	9.34874	10.65127	10.01056	10.66183	25
36	9.33874	9.98941	9.34933	10.65067	10.01059	10.66126	24
37	9.33931	9.98938	9.34992	10.65008	10.01062	10.66069	23
38	9.33987	9.98936	9.35051	10.64949	10.01064	10.66013	22
39	9.34043	9.98933	9.35111	10.64889	10.01067	10.65957	21
40	9.34100	9.98930	9.35170	10.64830	10.01070	10.65900	20
41	9.34156	9.98927	9.35229	10.64771	10.01073	10.65844	19
42	9.34212	9.98924	9.35288	10.64712	10.01076	10.65788	18
43	9.34268	9.98921	9.35347	10.64654	10.01079	10.65732	17
44	9.34324	9.98919	9.35405	10.64595	10.01081	10.65676	16
45	9.34380	9.98916	9.35464	10.64536	10.01084	10.65620	15
46	9.34436	9.98913	9.35523	10.64478	10.01087	10.65565	14
47	9.34491	9.98910	9.35581	10.64419	10.01090	10.65509	13
48	9.34547	9.98907	9.35640	10.64360	10.01093	10.6545[illegible]	12
49	9.34602	9.98904	9.35698	10.64302	10.01096	10.65390	11
50	9.34658	9.98901	9.35757	10.64243	10.01099	10.65342	10
51	9.34713	9.98899	9.35815	10.64185	10.01102	10.65287	9
52	9.34769	9.98896	9.35873	10.64127	10.01104	10.65231	8
53	9.34824	9.98893	9.35931	10.64069	10.01107	10.65176	7
54	9.34879	9.98890	9.35989	10.64011	10.01110	10.65121	6
55	9.34934	9.98887	9.36047	10.63953	10.01113	10.65066	5
56	9.34989	9.98884	9.36105	10.63895	10.01116	10.65011	4
57	9.35044	9.98881	9.36163	10.63837	10.01119	10.64956	3
58	9.35099	9.98878	9.36221	10.63779	10.01122	10.64901	2
59	9.35154	9.98875	9.36279	10.63721	10.01125	10.64846	1
60	9.35209	9.98872	9.36336	10.63664	10.01128	10.64791	0
		Sine.		Tang.		Secant.	Min.

77 *Degrees.*

A Table of Artificial Sines,

13 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.35209	9.98872	9.36336	10.63664	10.01128	10.64791	60
1	9.35264	9.98869	9.36394	10.63606	10.01131	10.64737	59
2	9.35318	9.98867	9.36452	10.63548	10.01133	10.64682	58
3	9.35373	9.98864	9.36509	10.63491	10.01136	10.64627	57
4	9.35427	9.98861	9.36566	10.63434	10.01139	10.64573	56
5	9.35482	9.98858	9.36624	10.63376	10.01142	10.64519	55
6	9.35536	9.98855	9.36681	10.63319	10.01145	10.64464	54
7	9.35590	9.98852	9.36738	10.63262	10.01148	10.64410	53
8	9.35644	9.98849	9.36795	10.63205	10.01151	10.64356	52
9	9.35698	9.98846	9.36852	10.63148	10.01154	10.64302	51
10	9.35752	9.98843	9.36909	10.63091	10.01157	10.64248	50
11	9.35806	9.98840	9.36966	10.63034	10.01160	10.64194	49
12	9.35860	9.98837	9.37023	10.62977	10.01163	10.64140	48
13	9.35914	9.98834	9.37080	10.62920	10.01166	10.64086	47
14	9.35968	9.98831	9.37137	10.62863	10.01169	10.64032	46
15	9.36022	9.98828	9.37193	10.62807	10.01172	10.63979	45
16	9.36075	9.98825	9.37250	10.62750	10.01175	10.63925	44
17	9.36129	9.98822	9.37306	10.62694	10.01178	10.63871	43
18	9.36182	9.98819	9.37363	10.62637	10.01181	10.63818	42
19	9.36236	9.98816	9.37419	10.62581	10.01184	10.63764	41
20	9.36289	9.98813	9.37476	10.62524	10.01187	10.63711	40
21	9.36342	9.98810	9.37532	10.62468	10.01190	10.63658	39
22	9.36395	9.98807	9.37588	10.62412	10.01193	10.63605	38
23	9.36449	9.98804	9.37644	10.62356	10.01196	10.63552	37
24	9.36502	9.98801	9.37700	10.62300	10.01199	10.63498	36
25	9.36555	9.98798	9.37756	10.62244	10.01202	10.63445	35
26	9.36608	9.98795	9.37812	10.62188	10.01205	10.63393	34
27	9.36660	9.98792	9.37868	10.62132	10.01208	10.63340	33
28	9.36713	9.98789	9.37924	10.62076	10.01211	10.63287	32
29	9.36766	9.98786	9.37980	10.62020	10.01214	10.63234	31
30	9.36819	9.98783	9.38035	10.61965	10.01217	10.63182	30
		Sine.		Tang.		Secant.	Min.

76 *Degrees.*

Tangents, and Secants.

13 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.36819	9.98783	9.38035	10.61965	10.01217	10.63182	30
31	9.36871	9.98780	9.38091	10.61909	10.01220	10.63129	29
32	9.36924	9.98777	9.38147	10.61853	10.01223	10.63076	28
33	9.36976	9.98774	9.38202	10.61798	10.01226	10.63024	27
34	9.37029	9.98771	9.38258	10.61743	10.01229	10.62972	26
35	9.37081	9.98768	9.38313	10.61687	10.01232	10.62919	25
36	9.37133	9.98765	9.38368	10.61632	10.01235	10.62867	24
37	9.37185	9.98762	9.38423	10.61577	10.01238	10.62815	23
38	9.37237	9.98759	9.38479	10.61521	10.01241	10.62763	22
39	9.37289	9.98756	9.38534	10.61466	10.01244	10.62711	21
40	9.37341	9.98753	9.38589	10.61411	10.01247	10.62659	20
41	9.37393	9.98750	9.38644	10.61356	10.01250	10.62607	19
42	9.37445	9.98747	9.38699	10.61301	10.01254	10.62555	18
43	9.37497	9.98743	9.38754	10.61246	10.01257	10.62503	17
44	9.37549	9.98740	9.38808	10.61192	10.01260	10.62451	16
45	9.37600	9.98737	9.38863	10.61137	10.01263	10.62400	15
46	9.37652	9.98734	9.38918	10.61082	10.01266	10.62348	14
47	9.37704	9.98731	9.38972	10.61028	10.01269	10.62297	13
48	9.37755	9.98728	9.39027	10.60973	10.01272	10.62245	12
49	9.37806	9.98725	9.39082	10.60919	10.01275	10.62194	11
50	9.37858	9.98722	9.39136	10.60864	10.01278	10.62142	10
51	9.37909	9.98719	9.39190	10.60810	10.01281	10.62091	9
52	9.37960	9.98716	9.39245	10.60755	10.01285	10.62040	8
53	9.38011	9.98712	9.39299	10.60701	10.01288	10.61989	7
54	9.38062	9.98709	9.39353	10.60645	10.01291	10.61938	6
55	9.38113	9.98706	9.39407	10.60593	10.01294	10.61887	5
56	9.38164	9.98703	9.39461	10.60539	10.01297	10.61836	4
57	9.38216	9.98700	9.39515	10.60485	10.01300	10.61785	3
58	9.38266	9.98697	9.39569	10.60431	10.01303	10.61734	2
59	9.38317	9.98694	9.39623	10.60377	10.01306	10.61683	1
60	9.38368	9.98690	9.39677	10.60323	10.01310	10.61633	0
		Sine		Tang.		Secant.	Min.

76 *Degrees.*

A Table of Artificial Sines,

14 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.38368	9.98690	9.39677	10.60323	10.01310	10.01633	60
1	9.38418	9.98687	9.39731	10.60269	10.01313	10.61582	59
2	9.38469	9.98684	9.39785	10.60215	10.01316	10.61531	58
3	9.38519	9.98681	9.39838	10.60162	10.01319	10.61481	57
4	9.38570	9.98678	9.39892	10.60108	10.01322	10.61430	56
5	9.38620	9.98675	9.39946	10.60055	10.01325	10.61380	55
6	9.38670	9.98671	9.39999	10.60001	10.01329	10.61330	54
7	9.38721	9.98668	9.40052	10.59948	10.01332	10.61279	53
8	9.38771	9.98665	9.40106	10.59894	10.01335	10.61229	52
9	9.38821	9.98662	9.40159	10.59841	10.01338	10.61179	51
10	9.38871	9.98659	9.40212	10.59788	10.01341	10.61129	50
11	9.38921	9.98656	9.40266	10.59734	10.01345	10.61079	49
12	9.38971	9.98652	9.40319	10.59681	10.01348	10.61029	48
13	9.39021	9.98649	9.40372	10.59628	10.01351	10.60979	47
14	9.39071	9.98646	9.40425	10.59575	10.01354	10.60929	46
15	9.39121	9.98643	9.40478	10.59522	10.01357	10.60879	45
16	9.39170	9.98640	9.40531	10.59469	10.01361	10.60830	44
17	9.39220	9.98636	9.40584	10.59416	10.01364	10.60780	43
18	9.39270	9.98633	9.40636	10.59364	10.01367	10.60731	42
19	9.39319	9.98630	9.40689	10.59311	10.01370	10.60681	41
20	9.39369	9.98627	9.40742	10.59258	10.01373	10.60632	40
21	9.39418	9.98623	9.40795	10.59206	10.01377	10.60582	39
22	9.39467	9.98620	9.40847	10.59153	10.01380	10.60533	38
23	9.39517	9.98617	9.40900	10.59100	10.01383	10.60483	37
24	9.39566	9.98614	9.40952	10.59048	10.01386	10.60434	36
25	9.39615	9.98610	9.41005	10.58996	10.01390	10.60385	35
26	9.39664	9.98607	9.41057	10.58943	10.01393	10.60336	34
27	9.39713	9.98604	9.41109	10.58891	10.01396	10.60287	33
28	9.39762	9.98601	9.41162	10.58839	10.01399	10.60238	32
29	9.39811	9.98597	9.41214	10.58786	10.01403	10.60189	31
30	9.39860	9.98594	9.41266	10.58734	10.01406	10.60140	30
		Sine.		Tang.		Secant.	Min.

75 *Degrees.*

Tangents, and Secants.

14 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.39860	9.98594	9.41266	10.58734	10.01406	10.60140	30
31	9.39909	9.98591	9.41318	10.58682	10.01409	10.60091	29
32	9.39958	9.98588	9.41370	10.58630	10.01412	10.60043	28
33	9.40006	9.98584	9.41422	10.58578	10.01416	10.59994	27
34	9.40055	9.98581	9.41474	10.58526	10.01419	10.59945	26
35	9.40104	9.98578	9.41526	10.58474	10.01422	10.59897	25
36	9.40152	9.98575	9.41578	10.58423	10.01426	10.59848	24
37	9.40201	9.98571	9.41629	10.58371	10.01429	10.59800	23
38	9.40249	9.98568	9.41681	10.58319	10.01432	10.59751	22
39	9.40297	9.98565	9.41733	10.58267	10.01435	10.59703	21
40	9.40346	9.98561	9.41784	10.58216	10.01439	10.59655	20
41	9.40394	9.98558	9.41836	10.58164	10.01442	10.59606	19
42	9.40442	9.98555	9.41887	10.58113	10.01445	10.59558	18
43	9.40490	9.98551	9.41939	10.58061	10.01449	10.59510	17
44	9.40538	9.98548	9.41990	10.58010	10.01452	10.59462	16
45	9.40586	9.98545	9.42042	10.57959	10.01455	10.59414	15
46	9.40634	9.98541	9.42093	10.57907	10.01459	10.59366	14
47	9.40682	9.98538	9.42144	10.57856	10.01462	10.59318	13
48	9.40730	9.98535	9.42195	10.57805	10.01465	10.59270	12
49	9.40778	9.98531	9.42246	10.57754	10.01469	10.59222	11
50	9.40825	9.98528	9.42297	10.57703	10.01472	10.59175	10
51	9.40873	9.98525	9.42348	10.57652	10.01475	10.59127	9
52	9.40921	9.98521	9.42399	10.57601	10.01479	10.59079	8
53	9.40968	9.98518	9.42450	10.57550	10.01482	10.59032	7
54	9.41016	9.98515	9.42501	10.57499	10.01485	10.58984	6
55	9.41063	9.98511	9.42552	10.57448	10.01489	10.58937	5
56	9.41111	9.98508	9.42603	10.57397	10.01492	10.58889	4
57	9.41158	9.98505	9.42653	10.57347	10.01496	10.58842	3
58	9.41205	9.98501	9.42704	10.57296	10.01499	10.58795	2
59	9.41252	9.98498	9.42755	10.57245	10.01502	10.58748	1
60	9.41300	9.98494	9.42805	10.57195	10.01506	10.58700	0
		Sine.		Tang.		Secant.	Min.

75 *Degrees.*

A Table of Artificial Sines,

15 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.41300	9.98494	9.42805	10.57195	10.01506	10.58700	60
1	9.41347	9.98491	9.42856	10.57144	10.01509	10.58653	59
2	9.41394	9.98488	9.42906	10.57094	10.01512	10.58606	58
3	9.41441	9.98484	9.42957	10.57043	10.01516	10.58559	57
4	9.41488	9.98481	9.43007	10.56993	10.01519	10.5851	56
5	9.41535	9.98477	9.43057	10.56943	10.01523	10.58465	55
6	9.41582	9.98474	9.43108	10.56893	10.01526	10.58419	54
7	9.41628	9.98471	9.43158	10.56842	10.01529	10.58372	53
8	9.41675	9.98467	9.43208	10.56792	10.01533	10.58325	52
9	9.41722	9.98464	9.43258	10.56742	10.01536	10.58278	51
10	9.41768	9.98460	9.43308	10.56692	10.01540	10.58232	50
11	9.41815	9.98457	9.43358	10.56642	10.01543	10.58185	49
12	9.41862	9.98454	9.43408	10.56592	10.01547	10.58139	48
13	9.41908	9.98450	9.43458	10.56542	10.01550	10.58092	47
14	9.41954	9.98447	9.43508	10.56492	10.01553	10.58046	46
15	9.42001	9.98443	9.43558	10.56442	10.01557	10.57999	45
16	9.42047	9.98440	9.43607	10.56393	10.01560	10.57953	44
17	9.42093	9.98436	9.43657	10.56343	10.01564	10.57907	43
18	9.42140	9.98433	9.43707	10.56293	10.01567	10.57861	42
19	9.42186	9.98429	9.43756	10.56244	10.01571	10.57814	41
20	9.42232	9.98426	9.43806	10.56194	10.01574	10.57768	40
21	9.42272	9.98422	9.43855	10.56145	10.01578	10.57722	39
22	9.42324	9.98419	9.43905	10.56095	10.01581	10.57676	38
23	9.42370	9.98416	9.43954	10.56046	10.01585	10.57630	37
24	9.42416	9.98412	9.44004	10.55996	10.01588	10.57584	36
25	9.42462	9.98409	9.44053	10.55947	10.01592	10.57539	35
26	9.42507	9.98405	9.44102	10.55898	10.01595	10.57493	34
27	9.42553	9.98402	9.44151	10.55849	10.01599	10.57447	33
28	9.42599	9.98398	9.44201	10.55799	10.01602	10.57401	32
29	9.42644	9.98395	9.44250	10.55750	10.01605	10.57356	31
30	9.42690	9.98391	9.44299	10.55701	10.01609	10.57310	30
		Sine.		Tang.		Secant.	Min.

74 *Degrees.*

Tangents, and Secants.

15 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.42690	9.98391	9.44299	10.55701	10.01609	10.57310	30
31	9.42735	9.98388	9.44348	10.55652	10.01612	10.57265	29
32	9.42781	9.98384	9.44397	10.55603	10.01616	10.57219	28
33	9.42826	9.98381	9.44446	10.55554	10.01620	10.57174	27
34	9.42872	9.98377	9.44495	10.55505	10.01623	10.57128	26
35	9.42917	9.98374	9.44544	10.55457	10.01627	10.57083	25
36	9.42962	9.98370	9.44592	10.55408	10.01630	10.57038	24
37	9.43008	9.98366	9.44641	10.55359	10.01634	10.56993	23
38	9.43053	9.98363	9.44690	10.55310	10.01637	10.56947	22
39	9.43098	9.98359	9.44738	10.55262	10.01641	10.56902	21
40	9.43143	9.98356	9.44787	10.55213	10.01644	10.56857	20
41	9.43188	9.98352	9.44836	10.55164	10.01648	10.56812	19
42	9.43233	9.98349	9.44884	10.55116	10.01651	10.56767	18
43	9.43278	9.98345	9.44933	10.55067	10.01655	10.56722	17
44	9.43323	9.98342	9.44981	10.55019	10.01658	10.56677	16
45	9.43368	9.98338	9.45029	10.54971	10.01662	10.56633	15
46	9.43412	9.98335	9.45078	10.54922	10.01666	10.56588	14
47	9.43457	9.98331	9.45126	10.54874	10.01669	10.56543	13
48	9.43502	9.98327	9.45174	10.54826	10.01672	10.56498	12
49	9.43546	9.98324	9.45223	10.54778	10.01676	10.56454	11
50	9.43591	9.98320	9.45271	10.54729	10.01680	10.56409	10
51	9.43635	9.98317	9.45319	10.54681	10.01683	10.56365	9
52	9.43680	9.98313	9.45367	10.54633	10.01687	10.56320	8
53	9.43724	9.98309	9.45415	10.54585	10.01691	10.56276	7
54	9.43769	9.98306	9.45463	10.54537	10.01694	10.56231	6
55	9.43813	9.98302	9.45511	10.54489	10.01698	10.56187	5
56	9.43857	9.98299	9.45559	10.54441	10.01701	10.56143	4
57	9.43901	9.98295	9.45606	10.54394	10.01705	10.56099	3
58	9.43946	9.98291	9.45654	10.54346	10.01709	10.56054	2
59	9.43990	9.98288	9.45702	10.54298	10.01712	10.56010	1
60	9.44034	9.98284	9.45750	10.54250	10.01716	10.55966	0
		Sine.		Tang.		Secant.	Min.

74 *Degrees.*

A Table of Artificial Sines,

16 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.44034	9.98284	9.45750	10.54250	10.01716	10.55966	60
1	9.44078	9.98281	9.45797	10.54203	10.01720	10.55922	59
2	9.44122	9.98277	9.45845	10.54155	10.01723	10.55878	58
3	9.44166	9.98273	9.45893	10.54108	10.01727	10.55834	57
4	9.44210	9.98270	9.45940	10.54060	10.01730	10.55790	56
5	9.44254	9.98266	9.45988	10.54013	10.01734	10.55747	55
6	9.44297	9.98262	9.46035	10.53965	10.01738	10.55703	54
7	9.44341	9.98259	9.46082	10.53918	10.01741	10.55659	53
8	9.44385	9.98255	9.46130	10.53870	10.01745	10.55615	52
9	9.44428	9.98251	9.46177	10.53823	10.01749	10.55572	51
10	9.44472	9.98248	9.46224	10.53776	10.01752	10.55528	50
11	9.44516	9.98244	9.46271	10.53729	10.01756	10.55485	49
12	9.44559	9.98240	9.46319	10.53681	10.01760	10.55441	48
13	9.44603	9.98237	9.46366	10.53634	10.01763	10.55398	47
14	9.44646	9.98233	9.46413	10.53587	10.01767	10.55354	46
15	9.44689	9.98229	9.46460	10.53540	10.01771	10.55311	45
16	9.44733	9.98226	9.46507	10.53493	10.01774	10.55267	44
17	9.44776	9.98222	9.46554	10.53446	10.01778	10.55224	43
18	9.44819	9.98218	9.46601	10.53399	10.01782	10.55181	42
19	9.44862	9.98215	9.46648	10.53352	10.01785	10.55138	41
20	9.44905	9.98211	9.46695	10.53306	10.01789	10.55095	40
21	9.44949	9.98207	9.46741	10.53259	10.01793	10.55052	39
22	9.44992	9.98204	9.46788	10.53212	10.01797	10.55009	38
23	9.45035	9.98200	9.46835	10.53165	10.01800	10.54966	37
24	9.45078	9.98196	9.46881	10.53119	10.01804	10.54923	36
25	9.45120	9.98192	9.46928	10.53072	10.01808	10.54880	35
26	9.45163	9.98189	9.46975	10.53025	10.01811	10.54837	34
27	9.45206	9.98185	9.47021	10.52979	10.01815	10.54794	33
28	9.45249	9.98181	9.47068	10.52932	10.01819	10.54751	32
29	9.45292	9.98177	9.47114	10.52886	10.01823	10.54709	31
30	9.45334	9.98174	9.47161	10.52840	10.01826	10.54666	30
		Sine.		Tang.		Secant.	Min.

73 *Degrees.*

Tangents, and Secants.

16 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.45334	9.98174	9.47161	10.52840	10.01826	10.54666	30
31	9.45377	9.98170	9.47207	10.52793	10.01830	10.54623	29
32	9.45419	9.98166	9.47253	10.52747	10.01834	10.54581	28
33	9.45462	9.98162	9.47300	10.52701	10.01838	10.54538	27
34	9.45504	9.98159	9.47346	10.52654	10.01841	10.54496	26
35	9.45547	9.98155	9.47392	10.52608	10.01845	10.54453	25
36	9.45589	9.98151	9.47438	10.52562	10.01849	10.54411	24
37	9.45632	9.98147	9.47484	10.52516	10.01853	10.54368	23
38	9.45674	9.98144	9.47530	10.52470	10.01856	10.54326	22
39	9.45716	9.98140	9.47576	10.52424	10.01860	10.54284	21
40	9.45758	9.98136	9.47622	10.52378	10.01864	10.54242	20
41	9.45801	9.98132	9.47668	10.52332	10.01868	10.54199	19
42	9.45843	9.98129	9.47714	10.52286	10.01872	10.54157	18
43	9.45885	9.98125	9.47760	10.52240	10.01875	10.54115	17
44	9.45927	9.98121	9.47806	10.52194	10.01879	10.54073	16
45	9.45969	9.98117	9.47852	10.52148	10.01883	10.54031	15
46	9.46011	9.98113	9.47898	10.52103	10.01887	10.53989	14
47	9.46053	9.98110	9.47943	10.52057	10.01891	10.53947	13
48	9.46095	9.98106	9.47989	10.52011	10.01894	10.53905	12
49	9.46136	9.98102	9.48035	10.51966	10.01898	10.53864	11
50	9.46178	9.98098	9.48080	10.51920	10.01902	10.53822	10
51	9.46220	9.98094	9.48126	10.51874	10.01906	10.53780	9
52	9.46266	9.98090	9.48171	10.51829	10.01910	10.53738	8
53	9.46303	9.98087	9.48217	10.51783	10.01913	10.53697	7
54	9.46345	9.98083	9.48262	10.51738	10.01917	10.53655	6
55	9.46386	9.98079	9.48308	10.51693	10.01921	10.53614	5
56	9.46428	9.98075	9.48353	10.51647	10.01925	10.53572	4
57	9.46469	9.98071	9.48398	10.51602	10.01929	10.53531	3
58	9.46511	9.98067	9.48444	10.51557	10.01933	10.53489	2
59	9.46555	9.98064	9.48489	10.51511	10.01937	10.53448	1
60	9.46594	9.98060	9.48534	10.51466	10.01940	10.53407	0
		Sine.		Tang.		Secant.	Min.

73 *Degrees.*

A Table of Artificial Sines,

17 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.46594	9.98060	9.48534	10.51466	10.01940	10.53407	60
1	9.46635	9.98056	9.48579	10.51421	10.01944	10.53365	59
2	9.46676	9.98052	9.48624	10.51376	10.01948	10.53324	58
3	9.46717	9.98048	9.48659	10.51331	10.01952	10.53283	57
4	9.46759	9.98044	9.48714	10.51286	10.01956	10.53242	56
5	9.46800	9.98040	9.48759	10.51241	10.01960	10.53200	55
6	9.46841	9.98036	9.48804	10.51196	10.01964	10.53159	54
7	9.46882	9.98033	9.48849	10.51151	10.01968	10.53118	53
8	9.46923	9.98019	9.48894	10.51106	10.01971	10.53077	52
9	9.46964	9.98025	9.48939	10.51061	10.01975	10.53037	51
10	9.47004	9.98021	9.48984	10.51016	10.01979	10.52995	50
11	9.47046	9.98017	9.49029	10.50971	10.01983	10.52955	49
12	9.47086	9.98013	9.49073	10.50927	10.01987	10.52914	48
13	9.47127	9.98009	9.49118	10.50882	10.01991	10.52873	47
14	9.47168	9.98005	9.49163	10.50837	10.01995	10.52823	46
15	9.47209	9.98001	9.49207	10.50793	10.01999	10.52791	45
16	9.47249	9.97997	9.49252	10.50748	10.02003	10.52751	44
17	9.47290	9.97993	9.49297	10.50704	10.02007	10.52710	43
18	9.47330	9.97990	9.49341	10.50659	10.02011	10.52670	42
19	9.47371	9.97986	9.49385	10.50615	10.02015	10.52629	41
20	9.47412	9.97982	9.49430	10.50570	10.02018	10.52589	40
21	9.47452	9.97978	9.49474	10.50526	10.02022	10.52548	39
22	9.47492	9.97974	9.49519	10.50481	10.02025	10.52508	38
23	9.47533	9.97970	9.49563	10.50437	10.02030	10.52467	37
24	9.47573	9.97966	9.49607	10.50393	10.02034	10.52427	36
25	9.47613	9.97962	9.49652	10.50349	10.02038	10.52387	35
26	9.47654	9.97958	9.49696	10.50304	10.02042	10.52346	34
27	9.47694	9.97954	9.49740	10.50260	10.02046	10.52306	33
28	9.47734	9.97950	9.49784	10.50216	10.02050	10.52266	32
29	9.47774	9.97946	9.49828	10.50172	10.02054	10.52226	31
30	9.47814	9.97942	9.49872	10.50128	10.02058	10.52186	30
		Sine.		Tang.		Secant.	Min.

72 *Degrees.*

Tangents, and Secants.

17 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.47814	9.97942	9.49872	10.50128	10.02058	10.52186	30
31	9.47854	9.97938	9.49916	10.50084	10.02062	10.52146	29
32	9.47894	9.97934	9.49960	10.50040	10.02066	10.52106	28
33	9.47934	9.97930	9.50004	10.49996	10.02070	10.52066	27
34	9.47974	9.97926	9.50048	10.49952	10.02074	10.52026	26
35	9.48014	9.97922	9.50092	10.49908	10.02078	10.51986	25
36	9.48054	9.97918	9.50136	10.49864	10.02082	10.51946	24
37	9.48094	9.97914	9.50180	10.49820	10.02086	10.51906	23
38	9.48133	9.97910	9.50224	10.49777	10.02090	10.51867	22
39	9.48173	9.97906	9.50267	10.49733	10.02094	10.51827	21
40	9.48213	9.97902	9.50311	10.49689	10.02098	10.51787	20
41	9.48253	9.97898	9.50355	10.49645	10.02102	10.51748	19
42	9.48292	9.97894	9.50398	10.49602	10.02106	10.51708	18
43	9.48332	9.97890	9.50442	10.49558	10.02110	10.51668	17
44	9.48371	9.97886	9.50485	10.49515	10.02114	10.51629	16
45	9.48411	9.97882	9.50529	10.49471	10.02118	10.51589	15
46	9.48450	9.97878	9.50572	10.49428	10.02122	10.51550	14
47	9.48490	9.97874	9.50616	10.49384	10.02126	10.51511	13
48	9.48529	9.97870	9.50659	10.49341	10.02130	10.51471	12
49	9.48568	9.97866	9.50703	10.49297	10.02135	10.51432	11
50	9.48608	9.97862	9.50746	10.49254	10.02139	10.51393	10
51	9.48647	9.97857	9.50789	10.49211	10.02143	10.51353	9
52	9.48686	9.97853	9.50833	10.49167	10.02147	10.51314	8
53	9.48725	9.97849	9.50876	10.49124	10.02151	10.51275	7
54	9.48764	9.97845	9.50919	10.49081	10.02155	10.51236	6
55	9.48803	9.97841	9.50962	10.49038	10.02159	10.51197	5
56	9.48842	9.97837	9.51005	10.48995	10.02163	10.51158	4
57	9.48881	9.97833	9.51049	10.48952	10.02167	10.51119	3
58	9.48920	9.97829	9.51092	10.48908	10.02171	10.51080	2
59	9.48959	9.97825	9.51135	10.48865	10.02175	10.51041	1
60	9.48998	9.97821	9.51178	10.48822	10.02179	10.51002	0
		Sine.		Tang.		Secant.	Min.

72 *Degrees.*

A Table of Artificial Sines,

18 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.48998	9.97821	9.51178	10.48822	10.02179	10.51002	60
1	9.49037	9.97817	9.51221	10.48779	10.02184	10.50963	59
2	9.49076	9.97814	9.51264	10.48737	10.02188	10.50924	58
3	9.49115	9.97808	9.51306	10.48694	10.02192	10.50885	57
4	9.49153	9.97804	9.51349	10.48651	10.02196	10.50847	56
5	9.49192	9.97800	9.51392	10.48608	10.02200	10.50807	55
6	9.49231	9.97796	9.51435	10.48565	10.02204	10.50769	54
7	9.49270	9.97792	9.51478	10.48522	10.02208	10.50731	53
8	9.49308	9.97788	9.51520	10.48480	10.02212	10.50692	52
9	9.49347	9.97784	9.51563	10.48437	10.02217	10.50653	51
10	9.49385	9.97779	9.51606	10.48394	10.02221	10.50615	50
11	9.49424	9.97775	9.51648	10.48352	10.02225	10.50576	49
12	9.49462	9.97771	9.51691	10.48309	10.02229	10.50538	48
13	9.49501	9.97767	9.51734	10.48267	10.02233	10.50500	47
14	9.49539	9.97763	9.51776	10.48224	10.02237	10.50461	46
15	9.49577	9.97759	9.51819	10.48181	10.02241	10.50423	45
16	9.49615	9.97754	9.51861	10.48139	10.02246	10.50385	44
17	9.49654	9.97750	9.51903	10.48097	10.02250	10.50346	43
18	9.49692	9.97746	9.51946	10.48054	10.02254	10.50308	42
19	9.49730	9.97742	9.51988	10.48012	10.02258	10.50270	41
20	9.49768	9.97738	9.52031	10.47970	10.02262	10.50232	40
21	9.49806	9.97734	9.52073	10.47927	10.02267	10.50194	39
22	9.49844	9.97729	9.52115	10.47885	10.02271	10.50156	38
23	9.49882	9.97725	9.52157	10.47843	10.02275	10.50118	37
24	9.49920	9.97721	9.52200	10.47801	10.02279	10.50080	36
25	9.49958	9.97717	9.52242	10.47758	10.02283	10.50042	35
26	9.49996	9.97713	9.52284	10.47716	10.02288	10.50004	34
27	9.50034	9.97708	9.52326	10.47674	10.02292	10.49966	33
28	9.50072	9.97704	9.52368	10.47632	10.02296	10.49928	32
29	9.50110	9.97700	9.52410	10.47590	10.02300	10.49890	31
30	9.50158	9.97696	9.52452	10.47548	10.02304	10.49852	30
		Sine.		Tang.		Secant.	Min.

71 *Degrees.*

Tangents, and Secants.

18 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.50148	9.97696	9.52452	10.47548	10.02304	10.49852	30
31	9.50185	9.97691	9.52494	10.47506	10.02309	10.49815	29
32	9.50223	9.97687	9.52536	10.47464	10.02313	10.49777	28
33	9.50261	9.97683	9.52578	10.47422	10.02317	10.49739	27
34	9.50298	9.97679	9.52620	10.47380	10.02321	10.49702	26
35	9.50336	9.97675	9.52662	10.47339	10.02326	10.49664	25
36	9.50374	9.97670	9.52703	10.47297	10.02330	10.49627	24
37	9.50411	9.97666	9.52745	10.47255	10.02334	10.49589	23
38	9.50449	9.97662	9.52787	10.47213	10.02338	10.49552	22
39	9.50486	9.97657	9.52829	10.47172	10.02343	10.49514	21
40	9.50523	9.97653	9.52870	10.47130	10.02347	10.49477	20
41	9.50561	9.97649	9.52912	10.47088	10.02351	10.49439	19
42	9.50598	9.97645	9.52954	10.47047	10.02355	10.49402	18
43	9.50635	9.97640	9.52996	10.47005	10.02360	10.49365	17
44	9.50673	9.97636	9.53037	10.46963	10.02364	10.49337	16
45	9.50710	9.97632	9.53078	10.46922	10.02368	10.49290	15
46	9.50747	9.97628	9.53120	10.46880	10.02373	10.49253	14
47	9.50784	9.97623	9.53161	10.46839	10.02377	10.49216	13
48	9.50821	9.97619	9.53203	10.46798	10.02381	10.49179	12
49	9.50859	9.97615	9.53244	10.46756	10.02385	10.49142	11
50	9.50896	9.97610	9.53285	10.46715	10.02390	10.49104	10
51	9.50933	9.97606	9.53327	10.46673	10.02394	10.49067	9
52	9.50970	9.97602	9.53368	10.46632	10.02398	10.49030	8
53	9.51007	9.97597	9.53409	10.46591	10.02403	10.48994	7
54	9.51043	9.97593	9.53450	10.46550	10.02407	10.48957	6
55	9.51080	9.97589	9.53492	10.46508	10.02411	10.48920	5
56	9.51117	9.97584	9.53533	10.46467	10.02416	10.48883	4
57	9.51154	9.97580	9.53574	10.46426	10.02420	10.48846	3
58	9.51191	9.97576	9.53615	10.46385	10.02424	10.48809	2
59	9.51228	9.97571	9.53656	10.46344	10.02429	10.48773	1
60	9.51264	9.97567	9.53697	10.46303	10.02433	10.48736	0
		Sine.		Tang.		Secant.	Min.

71 *Degrees.*

A Table of Artificial Sines,

19 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.51264	9.97567	9.53697	10.46303	10.02433	10.48736	60
1	9.51301	9.97563	9.53738	10.46262	10.02437	10.48699	59
2	9.51338	9.97558	9.53779	10.46221	10.02442	10.48663	58
3	9.51374	9.97554	9.53820	10.46180	10.02446	10.48626	57
4	9.51411	9.97550	9.53861	10.46139	10.02450	10.48589	56
5	9.51447	9.97545	9.53902	10.46098	10.02455	10.48553	55
6	9.51484	9.97541	9.53943	10.46057	10.02459	10.48516	54
7	9.51520	9.97537	9.53984	10.46016	10.02464	10.48480	53
8	9.51557	9.97532	9.54025	10.45976	10.02468	10.48443	52
9	9.51593	9.97528	9.54065	10.45935	10.02472	10.48407	51
10	9.51629	9.97523	9.54106	10.45894	10.02477	10.48371	50
11	9.51666	9.97519	9.54147	10.45853	10.02481	10.48334	49
12	9.51702	9.97515	9.54188	10.45813	10.02486	10.48298	48
13	9.51738	9.97510	9.54228	10.45772	10.02490	10.48262	47
14	9.51775	9.97506	9.54269	10.45731	10.02494	10.48226	46
15	9.51811	9.97501	9.54309	10.45691	10.02499	10.48189	45
16	9.51847	9.97497	9.54350	10.45650	10.02503	10.48153	44
17	9.51883	9.97493	9.54391	10.45610	10.02508	10.48117	43
18	9.51919	9.97488	9.54431	10.45569	10.02512	10.48081	42
19	9.51955	9.97484	9.54472	10.45528	10.02516	10.48045	41
20	9.51991	9.97479	9.54512	10.45488	10.02521	10.48009	40
21	9.52027	9.97475	9.54552	10.45448	10.02525	10.47973	39
22	9.52063	9.97470	9.54593	10.45407	10.02530	10.47937	38
23	9.52099	9.97466	9.54633	10.45367	10.02534	10.47901	37
24	9.52135	9.97461	9.54673	10.45327	10.02539	10.47865	36
25	9.52171	9.97457	9.54714	10.45286	10.02543	10.47829	35
26	9.52207	9.97453	9.54754	10.45246	10.02548	10.47793	34
27	9.52242	9.97448	9.54794	10.45206	10.02551	10.47758	33
28	9.52278	9.97444	9.54835	10.45166	10.02556	10.47722	32
29	9.52314	9.97439	9.54875	10.45125	10.02561	10.47686	31
30	9.52350	9.97435	9.54915	10.45085	10.02565	10.47651	30
		Sine.		Tang.		Secant.	Min.

70 *Degrees.*

Tangents, and Secants.

19 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.52350	9.97435	9.54915	10.45085	10.02565	10.47651	30
31	9.52385	9.97430	9.54955	10.45045	10.02570	10.47615	29
32	9.52421	9.97426	9.54995	10.45005	10.02574	10.47579	28
33	9.52456	9.97421	9.55035	10.44965	10.02579	10.47544	27
34	9.52492	9.97417	9.55075	10.44925	10.02583	10.47508	26
35	9.52528	9.97412	9.55115	10.44885	10.02587	10.47473	25
36	9.52563	9.97408	9.55155	10.44845	10.02592	10.47437	24
37	9.52598	9.97403	9.55195	10.44805	10.02597	10.47402	23
38	9.52634	9.97399	9.55235	10.44765	10.02601	10.47366	22
39	9.52669	9.97394	9.55275	10.44725	10.02606	10.47331	21
40	9.52705	9.97390	9.55315	10.44685	10.02610	10.47295	20
41	9.52740	9.97385	9.55355	10.44645	10.02615	10.47260	19
42	9.52775	9.97381	9.55395	10.44605	10.02619	10.47225	18
43	9.52811	9.97376	9.55434	10.44566	10.02624	10.47190	17
44	9.52846	9.97372	9.55474	10.44526	10.02628	10.47154	16
45	9.52881	9.97367	9.55514	10.44486	10.02633	10.47119	15
46	9.52916	9.97363	9.55554	10.44446	10.02637	10.47084	14
47	9.52951	9.97358	9.55593	10.44407	10.02642	10.47049	13
48	9.52986	9.97354	9.55633	10.44367	10.02647	10.47014	12
49	9.53022	9.97349	9.55673	10.44327	10.02651	10.46979	11
50	9.53057	9.97344	9.55712	10.44288	10.02656	10.46944	10
51	9.53092	9.97340	9.55752	10.44248	10.02660	10.46909	9
52	9.53127	9.97335	9.55791	10.44209	10.02665	10.46874	8
53	9.53161	9.97331	9.55831	10.44169	10.02669	10.46839	7
54	9.53196	9.97326	9.55870	10.44130	10.02674	10.46804	6
55	9.53231	9.97322	9.55910	10.44090	10.02679	10.46769	5
56	9.53266	9.97317	9.55949	10.44051	10.02683	10.46734	4
57	9.53301	9.97312	9.55989	10.44012	10.02688	10.46699	3
58	9.53336	9.97308	9.56028	10.43972	10.02692	10.46664	2
59	9.53370	9.97303	9.56067	10.43933	10.02697	10.46630	1
60	9.53405	9.97299	9.56107	10.43893	10.02701	10.46595	0
		Sine.		Tang.		Secant.	Min.

70 *Degrees.*

A Table of Artificial Sines,

20 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.53405	9.97299	9.56107	10.43893	10.02701	10.46595	60
1	9.53440	9.97294	9.56146	10.43854	10.02706	10.46560	59
2	9.53475	9.97289	9.56185	10.43818	10.02711	10.46526	58
3	9.53509	9.97285	9.56224	10.43776	10.02715	10.46491	57
4	9.53544	9.97280	9.56264	10.43736	10.02720	10.46456	56
5	9.53578	9.97276	9.56303	10.43697	10.02725	10.46422	55
6	9.53613	9.97271	9.56342	10.43658	10.02729	10.46387	54
7	9.53647	9.97266	9.56381	10.43619	10.02734	10.46353	53
8	9.53682	9.97262	9.56420	10.43580	10.02738	10.46318	52
9	9.53716	9.97257	9.56459	10.43541	10.02743	10.46284	51
10	9.53751	9.97252	9.56498	10.43502	10.02748	10.46249	50
11	9.53785	9.97248	9.56537	10.43463	10.02752	10.46215	49
12	9.53819	9.97243	9.56576	10.43424	10.02757	10.46181	48
13	9.53854	9.97238	9.56615	10.43385	10.02762	10.46146	47
14	9.53888	9.97234	9.56654	10.43346	10.02766	10.46112	46
15	9.53922	9.97229	9.56693	10.43307	10.02771	10.46078	45
16	9.53957	9.97225	9.56732	10.43268	10.02776	10.46044	44
17	9.53991	9.97220	9.56771	10.43229	10.02780	10.46009	43
18	9.54025	9.97215	9.56810	10.43190	10.02785	10.45975	42
19	9.54059	9.97211	9.56849	10.43151	10.02790	10.45941	41
20	9.54093	9.97206	9.56887	10.43113	10.02794	10.45907	40
21	9.54127	9.97201	9.56926	10.43074	10.02799	10.45873	39
22	9.54161	9.97196	9.56965	10.43035	10.02804	10.45839	38
23	9.54195	9.97192	9.57004	10.42996	10.02808	10.45805	37
24	9.54229	9.97187	9.57042	10.42958	10.02813	10.45771	36
25	9.54263	9.97182	9.57081	10.42919	10.02818	10.45737	35
26	9.54297	9.97178	9.57120	10.42881	10.02822	10.45703	34
27	9.54331	9.97173	9.57158	10.42842	10.02827	10.45669	33
28	9.54365	9.97168	9.57197	10.42803	10.02832	10.45635	32
29	9.54399	9.97164	9.57235	10.42765	10.02837	10.45601	31
30	9.54433	9.97159	9.57274	10.42726	10.02841	10.45568	30
		Sine.		Tang.		Secant.	Min.

69 *Degrees.*

Tangents, and Secants.

20 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.54433	9.97159	9.57274	10.42726	10.02841	10.45568	30
31	9.54466	9.97154	9.57312	10.42688	10.02846	10.45534	29
32	9.54500	9.97149	9.57351	10.42649	10.02851	10.45500	28
33	9.54534	9.97145	9.57389	10.42611	10.02855	10.45466	27
34	9.54567	9.97140	9.57428	10.42572	10.02860	10.45433	26
35	9.54601	9.97135	9.57466	10.42534	10.02865	10.45399	25
36	9.54635	9.97130	9.57504	10.42496	10.02870	10.45365	24
37	9.54668	9.97126	9.57543	10.42457	10.02874	10.45332	23
38	9.54702	9.97121	9.57581	10.42419	10.02879	10.45298	22
39	9.54735	9.97116	9.57619	10.42381	10.02884	10.45265	21
40	9.54769	9.97111	9.57658	10.42342	10.02889	10.45231	20
41	9.54802	9.97107	9.57696	10.42304	10.02893	10.45198	19
42	9.54836	9.97102	9.57734	10.42266	10.02898	10.45164	18
43	9.54869	9.97097	9.57772	10.42228	10.02903	10.45131	17
44	9.54903	9.97092	9.57810	10.42190	10.02908	10.45097	16
45	9.54936	9.97087	9.57849	10.42151	10.02913	10.45064	15
46	9.54969	9.97083	9.57887	10.42113	10.02917	10.45031	14
47	9.55003	9.97078	9.57925	10.42075	10.02922	10.44997	13
48	9.55036	9.97073	9.57963	10.42037	10.02927	10.44964	12
49	9.55069	9.97068	9.58001	10.41999	10.02932	10.44931	11
50	9.55102	9.97064	9.58039	10.41961	10.02937	10.44898	10
51	9.55136	9.97059	9.58077	10.41923	10.02941	10.44864	9
52	9.55169	9.97054	9.58115	10.41885	10.02946	10.44831	8
53	9.55202	9.97049	9.58153	10.41847	10.02951	10.44798	7
54	9.55235	9.97044	9.58191	10.41809	10.02956	10.44765	6
55	9.55268	9.97039	9.58229	10.41771	10.02961	10.44732	5
56	9.55301	9.97035	9.58267	10.41734	10.02966	10.44699	4
57	9.55334	9.97030	9.58304	10.41696	10.02970	10.44666	3
58	9.55367	9.97025	9.58342	10.41658	10.02975	10.44633	2
59	9.55400	9.97020	9.58380	10.41620	10.02980	10.44600	1
60	9.55433	9.97015	9.58418	10.41582	10.02985	10.44567	0
		Sine.		Tang.		Secant.	Min.

69 *Degrees.*

A Table of Artificial Sines,

21 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.55433	9.97015	9.58418	10.41582	10.02985	10.44567	60
1	9.55466	9.97010	9.58456	10.41545	10.02990	10.44534	59
2	9.55499	9.97006	9.58493	10.41507	10.02995	10.44501	58
3	9.55532	9.97001	9.58531	10.41469	10.02999	10.44468	57
4	9.55564	9.96996	9.58569	10.41431	10.03004	10.44436	56
5	9.55597	9.96991	9.58606	10.41394	10.03009	10.44401	55
6	9.55630	9.96986	9.58644	10.41356	10.03014	10.44370	54
7	9.55663	9.96981	9.58682	10.41319	10.03019	10.44337	53
8	9.55695	9.96976	9.58719	10.41281	10.03024	10.44305	52
9	9.55728	9.96971	9.58757	10.41243	10.03029	10.44272	51
10	9.55761	9.96967	9.58794	10.41200	10.03034	10.44239	50
11	9.55793	9.96962	9.58832	10.41168	10.03038	10.44207	49
12	9.55826	9.96957	9.58869	10.41131	10.03043	10.44174	48
13	9.55858	9.96952	9.58907	10.41093	10.03048	10.44142	47
14	9.55891	9.96947	9.58944	10.41056	10.03053	10.44109	46
15	9.55925	9.96942	9.58981	10.41019	10.03058	10.44076	45
16	9.55956	9.96937	9.59016	10.40981	10.03063	10.44044	44
17	9.55988	9.96932	9.59056	10.40944	10.03068	10.44012	43
18	9.56021	9.96927	9.59094	10.40907	1.003073	10.43979	42
19	9.56053	9.96922	9.59131	10.40869	10.03078	10.43947	41
20	9.56086	9.96917	9.59168	10.40832	10.03083	10.43915	40
21	9.56118	9.96912	9.59205	10.40795	10.03088	10.43882	39
22	9.56150	9.96908	9.59243	10.40757	10.03093	10.43850	38
23	9.56182	9.96903	9.59280	10.40720	10.03097	10.53818	37
24	9.56215	9.96898	9.59317	10.40683	10.03102	10.43785	36
25	9.56247	9.96892	9.59354	10.40646	10.03107	10.43753	35
26	9.56280	9.96888	9.59391	10.40609	10.03112	10.43721	34
27	9.56311	9.96883	9.59429	10.40572	10.03117	10.43689	33
28	9.56343	9.96878	9.59466	10.40534	10.03122	10.43657	32
29	9.56376	9.96873	9.59503	10.40497	10.03127	10.43625	31
30	9.56408	9.96868	9.59540	10.40460	10.03132	10.43592	30
		Sine.		Tang.		Secant.	Min.

68 *Degrees.*

Tangents, and Secants.

21 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.56408	9.96868	9.59540	10.40460	10.03132	10.43592	30
31	9.56440	9.96863	9.59577	10.40423	10.03137	10.43561	29
32	9.56472	9.96858	9.59614	10.40386	10.03142	10.43528	28
33	9.56504	9.96853	9.59651	10.40349	10.03147	10.43496	27
34	9.56536	9.96848	9.59688	10.40312	10.03152	10.43464	26
35	9.56568	9.96843	9.59725	10.40275	10.03157	10.43432	25
36	9.56600	9.96838	9.59762	10.40238	10.03162	10.43401	24
37	9.56631	9.96833	9.59799	10.40202	10.03167	10.43369	23
38	9.56663	9.96828	9.59835	10.40165	10.03172	10.43337	22
39	9.56695	9.96823	9.59872	10.40128	10.03177	10.43305	21
40	9.56727	9.96818	9.59909	10.40091	10.03182	10.43273	20
41	9.56759	9.96813	9.59946	10.40054	10.03187	10.43241	19
42	9.56790	9.96808	9.59983	10.40017	10.03192	10.43210	18
43	9.56822	9.96803	9.60019	10.39981	10.03197	10.43178	17
44	9.56854	9.96798	9.60056	10.39944	10.03202	10.43146	16
45	9.56884	9.96793	9.60093	10.39907	10.03207	10.43114	15
46	9.56917	9.96788	9.60130	10.39870	10.03212	10.43083	14
47	9.56949	9.96783	9.60166	10.39834	10.03217	10.43051	13
48	9.56980	9.96778	9.60203	10.39797	10.03223	10.43020	12
49	9.57012	9.96773	9.60240	10.39761	10.03228	10.42988	11
50	9.57044	9.96767	9.60276	10.39724	10.03233	10.42956	10
51	9.57075	9.96762	9.60313	10.39687	10.03238	10.42925	9
52	9.57107	9.96757	9.60349	10.39651	10.03243	10.42893	8
53	9.57138	9.96752	9.60386	10.39614	10.03248	10.42862	7
54	9.57170	9.96747	9.60422	10.39578	10.03253	10.42831	6
55	9.57201	9.96742	9.60459	10.39541	10.03258	10.42799	5
56	9.57232	9.96737	9.60495	10.39505	10.03263	10.42768	4
57	9.57264	9.96732	9.60532	10.39468	10.03268	10.42736	3
58	9.57295	9.96727	9.60568	10.39432	10.03273	10.42705	2
59	9.57326	9.96722	9.60605	10.39395	10.03278	10.42674	1
60	9.57358	9.96717	9.60641	10.39359	10.03283	10.42643	0
		Sine.		Tang.		Secant.	Min.

68 *Degrees.*

A Table of Artificial Sines,

22 Degrees.

Min.	Sine.		Tang.		Secant.		
0	9.57358	9.96717	9.60641	10.39359	10.03283	10.42643	60
1	9.57389	9.96712	9.60677	10.39323	10.03289	10.42611	59
2	9.57420	9.96706	9.60714	10.39286	10.03294	10.42580	58
3	9.57451	9.96701	9.60750	10.39250	10.03299	10.42549	57
4	9.57482	9.96696	9.60786	10.39214	10.03304	10.42518	56
5	9.57514	9.96691	9.60823	10.39178	10.03309	10.42487	55
6	9.57545	9.96686	9.60859	10.39141	10.03314	10.42455	54
7	9.57576	9.96681	9.60895	10.39105	10.03319	10.42424	53
8	9.57607	9.96676	9.60931	10.39069	10.03324	10.42393	52
9	9.57638	9.96671	9.60967	10.39033	10.03330	10.42362	51
10	9.57669	9.96665	9.61004	10.38996	10.03335	10.42331	50
11	9.57700	9.96660	9.61040	10.38960	10.03340	10.42300	49
12	9.57731	9.96655	9.61076	10.38924	10.03345	10.42269	48
13	9.57762	9.96650	9.61112	10.38888	10.03350	10.42238	47
14	9.57793	9.96645	9.61148	10.38852	10.03355	10.42207	46
15	9.57824	9.96640	9.61184	10.38816	10.03361	10.42176	45
16	9.57855	9.96634	9.61200	10.38780	10.03366	10.42146	44
17	9.57885	9.96629	9.61256	10.38744	10.03371	10.42115	43
18	9.57916	9.96624	9.61292	10.38708	10.03376	10.42084	42
19	9.57947	9.96619	9.61328	10.38672	10.03381	10.42053	41
20	9.57978	9.96614	9.61364	10.38636	10.03386	10.42023	40
21	9.58008	9.96609	9.61400	10.38600	10.03392	10.41992	39
22	9.58039	9.96603	9.61436	10.38564	10.03397	10.41961	38
23	9.58070	9.96598	9.61472	10.38528	10.03402	10.41930	37
24	9.58101	9.96593	9.61508	10.38492	10.03407	10.41900	36
25	9.58131	9.96588	9.61544	10.38457	10.03412	10.41869	35
26	9.58162	9.96582	9.61579	10.38421	10.03418	10.41838	34
27	9.58192	9.96577	9.61615	10.38385	10.03423	10.41800	33
28	9.58223	9.96572	9.61651	10.38349	10.03428	10.41777	32
29	9.58253	9.96567	5.61687	10.38313	10.03433	10.41747	31
30	9.58284	9.96562	9.61722	10.38278	10.03439	10.41716	30
		Sine.		Tang.		Secant.	Min.

67 Degrees.

Tangents, and Secants.

22 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.58284	9.96562	9.61722	10.38278	10.03439	10.41716	30
31	9.58314	9.96556	9.61758	10.38242	10.03444	10.41686	29
32	9.58345	9.96551	9.61794	10.38206	10.03449	10.41655	28
33	9.58375	9.96546	9.61830	10.38171	10.03454	10.41625	27
34	9.58406	9.96541	9.61865	10.38135	10.03459	10.41594	26
35	9.58436	9.96535	9.61901	10.38099	10.03465	10.41564	25
36	9.58467	9.96530	9.61936	10.38064	10.03470	10.41534	24
37	9.58497	9.96525	9.61972	10.38028	10.03475	10.41503	23
38	9.58527	9.96520	9.62008	10.37992	10.03481	10.41473	22
39	9.58557	9.96514	9.62043	10.37957	10.03486	10.41443	21
40	9.58588	9.96509	9.62079	10.37921	10.03491	10.41412	20
41	9.58618	9.96504	9.62114	10.37886	10.03496	10.41382	19
42	9.58648	9.96498	9.62150	10.37850	10.03502	10.41352	18
43	9.58678	9.96493	9.62185	10.37815	10.03507	10.41322	17
44	9.58709	9.96488	9.62221	10.37779	10.03512	10.41292	16
45	9.58739	9.96483	9.62256	10.37744	10.03517	10.41261	15
46	9.58769	9.96477	9.62292	10.37709	10.03523	10.41231	14
47	9.58799	9.96472	9.62327	10.37673	10.03528	10.41201	13
48	9.58829	9.96467	9.62362	10.37638	10.03533	10.41171	12
49	9.58859	9.96461	9.62398	10.37602	10.03539	10.41141	11
50	9.58889	9.96456	9.62433	10.37567	10.03544	10.41111	10
51	9.58919	9.96451	9.62468	10.37532	10.03549	10.41081	9
52	9.58949	9.96445	9.62504	10.37496	10.03555	10.41051	8
53	9.58979	9.96440	9.62539	10.37461	10.03560	10.41021	7
54	9.59009	9.96435	9.62574	10.37426	10.03566	10.40991	6
55	9.59039	9.96429	9.62609	10.37391	10.03571	10.40961	5
56	9.59069	9.96424	9.62645	10.37356	10.03576	10.40931	4
57	9.59098	9.96419	9.62680	10.37320	10.03581	10.40902	3
58	9.59128	9.96413	9.62715	10.37285	10.03587	10.40872	2
59	9.59158	9.96408	9.62750	10.37250	10.03592	10.40842	1
60	9.59188	9.96403	9.62785	10.37215	10.03597	10.40812	0
		Sine.		Tang.		Secant.	Min.

67 Degrees.

A Table of Artificial Sines,

23 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.59188	9.96403	9.62785	10.37215	10.03597	10.40812	60
1	9.59218	9.96397	9.62820	10.37180	10.03603	10.40782	59
2	9.59247	9.96392	9.62855	10.37145	10.03608	10.40753	58
3	9.59278	9.96387	9.62891	10.37110	10.03614	10.40723	57
4	9.59307	9.96381	9.62926	10.37075	10.03619	10.40693	56
5	9.59336	9.96376	9.62961	10.37039	10.03624	10.40664	55
6	9.59366	9.96370	9.62996	10.37004	10.03630	10.40634	54
7	9.59396	9.96365	9.63031	10.36969	10.03635	10.40604	53
8	9.59425	9.99360	9.63066	10.36934	10.03640	10.40575	52
9	9.59455	9.96354	9.63101	10.36900	10.03646	10.40545	51
10	9.59484	9.96349	9.63135	10.36865	10.03651	10.40516	50
11	9.59514	9.96343	9.63170	10.36830	10.03657	10.40486	49
12	9.59543	9.96338	9.63205	10.36795	10.03662	10.40457	48
13	9.59573	9.96333	9.63240	10.36760	10.03668	10.40427	47
14	9.59602	9.96327	9.63275	10.36725	10.03673	10.40398	46
15	9.59632	9.96322	9.63310	10.36690	10.03678	10.40369	45
16	9.59661	9.96316	9.63341	10.36655	10.03684	10.40339	44
17	9.59690	9.96311	9.63380	10.36621	10.03689	10.40310	43
18	9.59720	9.96305	9.63414	10.36586	10.03695	10.40280	42
19	9.59749	9.96300	9.63449	10.36551	10.03700	10.40251	41
20	9.59778	9.96295	9.63484	10.30516	10.03706	10.40222	40
21	9.59808	9.96289	9.63519	10.36482	10.03711	10.40193	39
22	9.59837	9.96284	9.63553	10.36447	10.03716	10.40163	38
23	9.59866	9.96278	9.63588	10.36412	10.03722	10.40134	37
24	9.59895	9.96273	9.63623	10.36377	10.03727	10.40105	36
25	9.59924	9.96267	9.63657	10.36343	10.03732	10.40076	35
26	9.59954	9.96262	9.63692	10.36308	10.03738	10.40046	34
27	9.59983	9.96256	9.63727	10.36274	10.03744	10.40017	33
28	9.60012	9.96251	9.63761	10.36239	10.03749	10.39988	32
29	9.60041	9.96245	9.63796	10.36204	10.03755	10.39959	31
30	9.60070	9.96240	9.62830	10.36170	10.03760	10.39930	30
		Sine.		Tang.		Secant.	Min.

66 *Degrees.*

Tangents, and Secants.

23 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.60070	9.96240	9.63830	10.36170	10.03760	10.39930	30
31	9.60099	9.96234	9.63865	10.36135	10.03766	10.39901	29
32	9.60128	9.96229	9.63899	10.36101	10.03771	10.39872	28
33	9.60157	9.96223	9.63934	10.36066	10.03777	10.39843	27
34	9.60186	9.96218	9.63968	10.36032	10.03782	10.39814	26
35	9.60215	9.96212	9.64003	10.35997	10.03788	10.39785	25
36	9.60244	9.96207	9.64037	10.35963	10.03793	10.39756	24
37	9.60273	9.96201	9.64072	10.35928	10.03799	10.39727	23
38	9.60302	9.96196	9.64106	10.35894	10.03804	10.39698	22
39	9.60331	9.96190	9.64140	10.35860	10.03810	10.39670	21
40	9.60359	9.96185	9.64175	10.35825	10.03815	10.39641	20
41	9.60388	9.96179	9.64209	10.35791	10.03821	10.39612	19
42	9.60417	9.96174	9.64243	10.35757	10.03826	10.39583	18
43	9.60446	9.96168	9.64278	10.35722	10.03832	10.39554	17
44	9.60475	9.96162	9.64312	10.35688	10.03838	10.39526	16
45	9.60503	9.96157	9.64346	10.35654	10.03843	10.39497	15
46	9.60532	9.96151	9.64381	10.35619	10.03849	10.39468	14
47	9.60561	9.96146	9.64415	10.35585	10.03854	10.39439	13
48	9.60589	9.96140	9.64449	10.35551	10.03860	10.39411	12
49	9.60618	9.96135	9.64483	10.35517	10.03865	10.39382	11
50	9.60647	9.96129	9.64517	10.35483	10.03871	10.39354	10
51	9.60675	9.96124	9.64552	10.35448	10.03877	10.39325	9
52	9.60704	9.96118	9.64586	10.35414	10.03882	10.39296	8
53	9.60732	9.96112	9.64620	10.35380	10.03888	10.39268	7
54	9.60761	9.96107	9.64654	10.35346	10.03893	10.39239	6
55	9.60789	9.96101	9.64688	10.35312	10.03899	10.39211	5
56	9.60818	9.96096	9.64722	10.35278	10.03905	10.39182	4
57	9.60846	9.96090	9.64756	10.35244	10.03910	10.39153	3
58	9.60875	9.96084	9.64790	10.35210	10.03916	10.39126	2
59	9.60903	9.96079	9.64824	10.35176	10.03921	10.39097	1
60	9.60931	9.96073	9.64858	10.35142	10.03927	10.39069	0
		Sine.		Tang.		Secant.	Min.

66 *Degrees.*

A Table of Artificial Sines,

24 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.60931	9.96073	9.64858	10.35142	10.03927	10.39069	60
1	9.60960	9.96067	9.64892	10.35108	10.03933	10.39040	59
2	9.60988	9.96062	9.64926	10.35074	10.03938	10.39012	58
3	9.61016	9.96056	9.64960	10.35040	10.03944	10.38984	57
4	9.61045	9.96051	9.64994	10.35006	10.03950	10.38955	56
5	9.61073	9.96045	9.65028	10.34972	10.03955	10.38927	55
6	9.61101	9.96039	9.65062	10.34938	10.03961	10.38899	54
7	9.61129	9.96034	9.65096	10.34904	10.03967	10.38871	53
8	9.61158	9.96028	9.65130	10.34870	10.03972	10.38842	52
9	9.61186	9.96022	9.65164	10.34836	10.03978	10.38814	51
10	9.61214	9.96017	9.65197	10.34803	10.03983	10.38786	50
11	9.61242	9.96011	9.65231	10.34769	10.03989	10.38758	49
12	9.61270	9.96005	9.65265	10.34735	10.03995	10.38730	48
13	9.61298	9.96000	9.65299	10.34701	10.04001	10.38702	47
14	9.61326	9.95994	9.65333	10.34667	10.04006	10.38674	46
15	9.61355	9.95988	9.65366	10.34634	10.04012	10.38646	45
16	9.61383	9.95983	9.65400	10.34600	10.04018	10.38618	44
17	9.61411	9.95977	9.65434	10.34566	10.04023	10.38590	43
18	9.61439	9.95971	9.65467	10.34533	10.04029	10.38562	42
19	9.61467	9.95965	9.65501	10.34499	10.04035	10.38534	41
20	9.61494	9.95960	9.65535	10.34465	10.04040	10.38506	40
21	9.61522	9.95954	9.65568	10.34432	10.04046	10.38478	39
22	9.61550	9.95948	9.65602	10.34398	10.04052	10.38450	38
23	9.61578	9.95943	9.65636	10.34364	10.04058	10.38422	37
24	9.61606	9.95937	9.65669	10.34331	10.04063	10.38394	36
25	9.61634	9.95931	9.65703	10.34297	10.04069	10.38366	35
26	9.61662	9.95925	9.65736	10.34264	10.04075	10.38338	34
27	9.61689	9.95920	9.65770	10.34230	10.04081	10.38311	33
28	9.61717	9.95914	9.65803	10.34197	10.04086	10.38283	32
29	9.61745	9.95908	9.65837	10.34163	10.04092	10.38255	31
30	9.61773	9.95902	9.65870	10.34130	10.04098	10.38227	30
		Sine.		Tang.		Secant.	Min.

65 *Degrees.*

Tangents, and Secants.

24 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.61773	9.95902	9.65870	10.34130	10.04098	10.38227	30
31	9.61800	9.95897	9.65904	10.34096	10.04104	10.38200	29
32	9.61828	9.95891	9.65937	10.34063	10.04109	10.38172	28
33	9.61856	9.95885	9.65971	10.34029	10.04115	10.38144	27
34	9.61883	9.95879	9.66004	10.33996	10.04121	10.38117	26
35	9.61911	9.95873	9.66038	10.33962	10.04127	10.38089	25
36	9.61939	9.95868	9.66071	10.33929	10.04132	10.38061	24
37	9.61966	9.95862	9.66104	10.33896	10.04138	10.38034	23
38	9.61994	9.95856	9.66138	10.33862	10.04144	10.38006	22
39	9.62021	9.95850	9.66171	10.33829	10.04150	10.37979	21
40	9.62049	9.95845	9.66204	10.33796	10.04156	10.37951	20
41	9.62076	9.95839	9.66238	10.33762	10.04161	10.37921	19
42	9.62104	9.95833	9.66271	10.33729	10.04167	10.37896	18
43	9.62131	9.95827	9.66304	10.33696	10.04173	10.37869	17
44	9.62159	9.95821	9.66337	10.33663	10.04179	10.37841	16
45	9.62186	9.95815	9.66371	10.33629	10.04185	10.37814	15
46	9.62214	9.95810	9.66404	10.33596	10.04190	10.37787	14
47	9.62241	9.95804	9.66437	10.33563	10.04196	10.37759	13
48	9.62268	9.95798	9.66470	10.33530	10.04202	10.37732	12
49	9.62296	9.95792	9.66504	10.33497	10.04208	10.37704	11
50	9.62323	9.95786	9.66537	10.33463	10.04214	10.37677	10
51	9.62350	9.95780	9.66570	10.33430	10.04220	10.37650	9
52	9.62377	9.95775	9.66603	10.33397	10.04225	10.37623	8
53	9.62405	9.95769	9.66636	10.33364	10.04231	10.37595	7
54	9.62432	9.95763	9.66669	10.33331	10.04237	10.37568	6
55	9.62459	9.95757	9.66702	10.33298	10.04243	10.37541	5
56	9.62486	9.95751	9.66735	10.33265	10.04249	10.37514	4
57	9.62514	9.95745	9.66768	10.33232	10.04255	10.37487	3
58	9.62541	9.95739	9.66801	10.33199	10.04261	10.37459	2
59	9.62568	9.95734	9.66834	10.33166	10.04267	10.37432	1
60	9.62595	9.95728	9.66867	10.33133	10.04272	10.37405	0
		Sine.		Tang.		Secant.	Min.

65 *Degrees.*

A Table of Artificial Sines,

25 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.62595	9.95728	9.66867	10.33133	10.04272	10.37405	60
1	9.62622	9.95722	9.66900	10.33100	10.04278	10.37378	59
2	9.62649	9.95716	9.66933	10.33067	10.04284	10.37351	58
3	9.62676	9.95710	9.66966	10.33034	10.04290	10.37324	57
4	9.62703	9.95704	9.66999	10.33001	10.04296	10.37297	56
5	9.62730	9.95698	9.67032	10.32968	10.04302	10.37270	55
6	9.62757	9.95692	9.67065	10.32935	10.04308	10.37243	54
7	9.62784	9.95686	9.67098	10.32902	10.04314	10.37216	53
8	9.62811	9.95680	9.67131	10.32869	10.04320	10.37189	52
9	9.62838	9.95674	9.67163	10.32837	10.04326	10.37162	51
10	9.62865	9.95668	9.67196	10.32804	10.04332	10.37135	50
11	9.62892	9.95663	9.67239	10.32771	10.04338	10.37108	49
12	9.62918	9.95657	9.67262	10.32738	10.04343	10.37082	48
13	9.62945	9.95651	9.67295	10.32705	10.04349	10.37055	47
14	9.62972	9.95645	9.67327	10.32673	10.04355	10.37028	46
15	9.62999	9.95639	9.67360	10.32640	10.04361	10.37001	45
16	9.63025	9.95633	9.67393	10.32607	10.04367	10.36974	44
17	9.63052	9.95627	9.67426	10.32574	10.04373	10.36948	43
18	9.63079	9.95621	9.67458	10.32542	10.04379	10.36921	42
19	9.63106	9.95615	9.67491	10.32509	10.04385	10.36894	41
20	9.63133	9.95009	9.67524	10.32476	10.04391	10.36807	40
21	9.63159	9.95603	9.67556	10.32444	10.04397	10.36841	39
22	9.63186	9.95597	9.67589	10.32411	10.04403	10.36814	38
23	9.63213	9.95591	9.67622	10.32378	10.04409	10.36787	37
24	9.63239	9.95585	9.67654	10.32346	10.04415	10.36761	36
25	9.63266	9.95579	9.67687	10.32313	10.04421	10.36734	35
26	9.63292	9.95573	9.67719	10.32281	10.04427	10.36708	34
27	9.63319	9.95567	9.67752	10.32248	10.04433	10.36681	33
28	9.63345	9.95561	9.67785	10.32215	10.04439	10.36655	32
29	9.63372	9.95555	9.67817	10.32183	10.04445	10.36628	31
30	9.63398	9.95549	9.67850	10.32150	10.04451	10.36602	30
		Sine.		Tang.		Secant.	Min.

64 *Degrees.*

Tangents, and Secants.

25 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.63398	9.95549	9.67850	10.32150	10.04451	10.36602	30
31	9.63425	9.95543	9.67882	10.32118	10.04457	10.36575	29
32	9.63451	9.95537	9.67915	10.32085	10.04463	10.36549	28
33	9.63478	9.95531	9.67947	10.32053	10.04469	10.36522	27
34	9.63504	9.95525	9.67980	10.32021	10.04475	10.36496	26
35	9.63531	9.95519	9.68012	10.31988	10.04481	10.36469	25
36	9.63557	9.95513	9.68044	10.31956	10.04487	10.36443	24
37	9.63583	9.95507	9.68077	10.31923	10.04494	10.36417	23
38	9.63610	9.95501	9.68109	10.31891	10.04500	10.36390	22
39	9.63636	9.95494	9.68142	10.31858	10.04506	10.36364	21
40	9.63662	9.95488	9.68174	10.31826	10.04512	10.36338	20
41	9.63689	9.95482	9.68206	10.31794	10.04518	10.36311	19
42	9.63715	9.95476	9.68239	10.31761	10.04524	10.36285	18
43	9.63741	9.95470	9.68271	10.31729	10.04530	10.36259	17
44	9.63767	9.95464	9.68303	10.31697	10.04536	10.36233	16
45	9.63794	9.95458	9.68336	10.31664	10.04542	10.36207	15
46	9.63820	9.95452	9.68368	10.31632	10.04548	10.36180	14
47	9.63846	9.95446	9.68400	10.31600	10.04554	10.36154	13
48	9.63872	9.95440	9.68432	10.31568	10.04560	10.36128	12
49	9.63898	9.95434	9.68465	10.31535	10.04567	10.36102	11
50	9.63924	9.95427	9.68497	10.31503	10.04573	10.36076	10
51	9.63950	9.95421	9.68529	10.31471	10.04579	10.36050	9
52	9.63976	9.95415	9.68561	10.31439	10.04585	10.36024	8
53	9.64002	9.95409	9.68593	10.31407	10.04591	10.35998	7
54	9.64028	9.95403	9.68626	10.31375	10.04597	10.35972	6
55	9.64054	9.95397	9.68658	10.31342	10.04603	10.35946	5
56	9.64080	9.95391	9.68690	10.31310	10.04609	10.35920	4
57	9.64106	9.95385	9.68722	10.31278	10.04616	10.35894	3
58	9.64132	9.95378	9.68754	10.31246	10.04622	10.35868	2
59	9.64158	9.95372	9.68786	10.31214	10.04628	10.35842	1
60	9.64184	9.95366	9.688[illegible]8	10.31182	10.04634	10.35816	0
		Sine.		Tang.		Secant.	Min.

64 *Degrees.*

A Table of Artificial Sines,

26 Degrees.

Min.	Sine.		Tang.		Secant.		
0	9.64184	9.95366	9.68818	10.31182	10.04634	10.35816	60
1	9.64210	9.95360	9.68850	10.31150	10.04640	10.35790	59
2	9.64236	9.95354	9.68882	10.31118	10.04646	10.35764	58
3	9.64262	9.95348	9.68914	10.31086	10.04653	10.35738	57
4	9.64288	9.95341	9.68946	10.31054	10.04659	10.35712	56
5	9.64314	9.95335	9.68978	10.31022	10.04665	10.35687	55
6	9.64339	9.95329	9.69010	10.30990	10.04671	10.35661	54
7	9.64365	9.95323	9.69042	10.30958	10.04677	10.35635	53
8	9.64391	9.95317	9.69074	10.30926	10.04683	10.35609	52
9	9.64417	9.95310	9.69106	10.30894	10.04690	10.35584	51
10	9.64442	9.95304	9.69138	10.30862	10.04696	10.35558	50
11	9.64468	9.95298	9.69170	10.30830	10.04702	10.35532	49
12	9.64494	9.95292	9.69202	10.30798	10.04708	10.35506	48
13	9.64519	9.95286	9.69234	10.30766	10.04715	10.35481	47
14	9.64545	9.95279	9.69266	10.30734	10.04721	10.35455	46
15	9.64571	9.95273	9.69298	10.30703	10.04727	10.35429	45
16	9.64596	9.95267	9.69329	10.30671	10.04733	10.35404	44
17	9.64622	9.95261	9.69361	10.30639	10.04739	10.35378	43
18	9.64647	9.95254	9.69393	10.30607	10.04746	10.35353	42
19	9.64673	9.95248	9.69425	10.30575	10.04752	10.35327	41
20	9.64698	9.95242	9.69457	10.30543	10.04758	10.35302	40
21	9.64724	9.95236	9.69488	10.30512	10.04764	10.35276	39
22	9.64749	9.95229	9.69520	10.30480	10.04771	10.35251	38
23	9.64775	9.95223	9.69552	10.30448	10.04777	10.35225	37
24	9.64800	9.95217	9.69584	10.30416	10.04783	10.35200	36
25	9.64826	9.95211	9.69615	10.30385	10.04789	10.35174	35
26	9.64851	9.95204	9.69647	10.30353	10.04796	10.35149	34
27	9.64877	9.95198	9.69679	10.30321	10.04802	10.35123	33
28	9.64902	9.95192	9.69710	10.30290	10.04808	10.35098	32
29	9.64927	9.95185	9.69742	10.30258	10.04815	10.35073	31
30	9.64953	9.95179	9.69774	10.30226	10.04831	10.35047	30
		Sine.		Tang.		Secant.	Min.

63 Degrees.

Tangents, and Secants.

26 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.64953	9.95179	9.69774	10.30226	10.04821	10.35047	30
31	9.64978	9.95173	9.69805	10.30195	10.04827	10.35022	29
32	9.65003	9.95167	9.69837	10.30163	10.04834	10.34997	28
33	9.65029	9.95160	9.69869	10.30132	10.04840	10.34971	27
34	9.65054	9.95154	9.69900	10.30100	10.04846	10.34946	26
35	9.65079	9.95148	9.69932	10.30068	10.04852	10.34921	25
36	9.65104	9.95141	9.69963	10.30037	10.04859	10.34896	24
37	9.65130	9.95135	9.69995	10.30005	10.04865	10.34870	23
38	9.65155	9.95129	9.70026	10.29974	10.04871	10.34845	22
39	9.65180	9.95122	9.70058	10.29942	10.04878	10.34820	21
40	9.65205	9.95116	9.70089	10.29911	10.04884	10.34795	20
41	9.65230	9.95110	9.70121	10.29879	10.04890	10.34770	19
42	9.65256	9.95103	9.70152	10.29848	10.04897	10.34745	18
43	9.65281	9.95097	9.70184	10.29816	10.04903	10.34719	17
44	9.65306	9.95091	9.70215	10.29785	10.04910	10.34694	16
45	9.65331	9.95084	9.70247	10.29753	10.04916	10.34669	15
46	9.65356	9.95078	9.70278	10.29722	10.04922	10.34644	14
47	9.65381	9.95071	9.70310	10.29691	10.04929	10.34619	13
48	9.65406	9.95065	9.70341	10.29659	10.04935	10.34594	12
49	9.65431	9.95059	9.70372	10.29628	10.04941	10.34569	11
50	9.65456	9.95052	9.70404	10.29596	10.04948	10.34544	10
51	9.65481	9.95046	9.70435	10.29565	10.04954	10.34519	9
52	9.65506	9.95039	9.70466	10.29534	10.04961	10.34494	8
53	9.65531	9.95033	9.70498	10.29502	10.04967	10.34469	7
54	9.65556	9.95027	9.70529	10.29471	10.04973	10.34444	6
55	9.65581	9.95020	9.70560	10.29440	10.04980	10.34420	5
56	9.65605	9.95014	9.70592	10.29408	10.04986	10.34395	4
57	9.65630	9.95007	9.70623	10.29377	10.04993	10.34370	3
58	9.65655	9.95000	9.70654	10.29346	10.04999	10.34345	2
59	9.65680	9.94995	9.70685	10.29315	10.05006	10.34320	1
60	9.65705	9.94988	9.70717	10.29283	10.05012	10.34295	0
		Sine.		Tang.		Secant.	Min.

63 *Degrees.*

A Table of Artificial Sines,

27 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.65705	9.94988	9.70717	10.29283	10.05012	10.34295	60
1	9.65730	9.94982	9.70748	10.29252	10.05018	10.34271	59
2	9.65754	9.94975	9.70779	10.29221	10.05025	10.34246	58
3	9.65779	9.94969	9.70810	10.29190	10.05031	10.34221	57
4	9.65804	9.94962	9.70841	10.29159	10.05038	10.34196	56
5	9.65828	9.94956	9.70873	10.29127	10.05044	10.34172	55
6	9.65853	9.94949	9.70904	10.29096	10.05051	10.34147	54
7	9.65878	9.94943	9.70935	10.29065	10.05057	10.34122	53
8	9.65903	9.94936	9.70966	10.29034	10.05064	10.34098	52
9	9.65927	9.94930	9.70997	10.29003	10.05070	10.34073	51
10	9.65952	9.94924	9.71028	10.28972	10.05077	10.34048	50
11	9.65975	9.94917	9.71059	10.28941	10.05083	10.34024	49
12	9.66001	9.94911	9.71090	10.28910	10.05090	10.33999	48
13	9.66026	9.94904	9.71122	10.28879	10.05096	10.33975	47
14	9.66050	9.94898	9.71153	10.28848	10.05103	10.33950	46
15	9.66075	9.94891	9.71184	10.28816	10.05109	10.33925	45
16	9.66099	9.94885	9.71215	10.28785	10.05116	10.33901	44
17	9.66124	9.94878	9.71246	10.28754	10.05122	10.33876	43
18	9.66148	9.94872	9.71277	10.28723	10.05129	10.33852	42
19	9.66172	9.94865	9.71308	10.28692	10.05135	10.33827	41
20	9.66197	9.94858	9.71339	10.28661	10.05142	10.33803	40
21	9.66221	9.94852	9.71370	10.28630	10.05148	10.33779	39
22	9.66246	9.94845	9.71401	10.28600	10.05155	10.33754	38
23	9.66270	9.94839	9.71431	10.28569	10.05161	10.33730	37
24	9.66295	9.94832	9.71462	10.28538	10.05168	10.33705	36
25	9.66319	9.94826	9.71493	10.28507	10.05174	10.33681	35
26	9.66343	9.94819	9.71524	10.28476	10.05181	10.33657	34
27	9.66368	9.94813	9.71555	10.28445	10.05187	10.33632	33
28	9.66392	9.94806	9.71586	10.28414	10.05194	10.33608	32
29	9.66416	9.94800	9.71617	10.28383	10.05201	10.33584	31
30	9.66441	9.94793	9.71648	10.28352	10.05207	10.33559	30
		Sine.		Tang.		Secant.	Min.

62 *Degrees.*

Tangents, and Secants.

27 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.66441	9.94793	9.71648	10.28352	10.05207	10.33559	30
31	9.66465	9.94786	9.71679	10.28322	10.05214	10.33535	29
32	9.66489	9.94780	9.71709	10.28291	10.05220	10.33511	28
33	9.66513	9.94773	9.71740	10.28260	10.05227	10.33487	27
34	9.66538	9.94767	9.71771	10.28229	10.05233	10.33463	26
35	9.66562	9.94760	9.71802	10.28198	10.05240	10.33438	25
36	9.66586	9.94753	9.71833	10.28168	10.05247	10.33414	24
37	9.66610	9.94747	9.71863	10.28137	10.05253	10.33390	23
38	9.66634	9.94740	9.71894	10.28106	10.05260	10.33366	22
39	9.66658	9.94734	9.71925	10.28075	10.05267	10.33342	21
40	9.66682	9.94727	9.71956	10.28045	10.05273	10.33318	20
41	9.66707	9.94720	9.71986	10.28914	10.05280	10.33294	19
42	9.66731	9.94714	9.72017	10.27983	10.05286	10.33270	18
43	9.66755	9.94707	9.72048	10.27952	10.05293	10.33245	17
44	9.66779	9.94700	9.72078	10.27922	10.05300	10.33221	16
45	9.66803	9.94694	9.72109	10.27891	10.05306	10.33197	15
46	9.66827	9.94687	9.72139	10.27860	10.03313	10.33173	14
47	9.66851	9.94680	9.72170	10.27830	10.05320	10.33149	13
48	9.66875	9.94674	9.72201	10.27799	10.05326	10.33125	12
49	9.66899	9.94667	9.72232	10.27769	10.05333	10.33101	11
50	9.66923	9.94660	9.72262	10.27738	10.05340	10.33078	10
51	9.66946	9.94654	9.72293	10.27707	10.05346	10.33054	9
52	9.66970	9.94647	9.72323	10.27677	10.05353	10.33030	8
53	9.66994	9.94640	9.72354	10.27646	10.05360	10.33006	7
54	9.67018	9.94634	9.72384	10.27616	10.05366	10.32982	6
55	9.67042	9.94627	9.72415	10.27585	10.05373	10.32958	5
56	9.67066	9.94620	9.72445	10.27555	10.05380	10.32934	4
57	9.67090	9.94614	9.72476	10.27524	10.05386	10.32910	3
58	9.67113	9.94607	9.72507	10.27494	10.05393	10.32887	2
59	9.67137	9.94600	9.72537	10.27463	10.05400	10.32863	1
60	9.67161	9.94594	9.72567	10.27433	10.05407	10.32839	0
		Sine.		Tang.		Secant.	Min.

62 *Degrees.*

A Table of Artificial Sines,

28 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.67161	9.94594	9.72567	10.27433	10.05407	10.32839	60
1	9.67185	9.94587	9.72598	10.27402	10.05413	10.32815	59
2	9.67208	9.94580	9.72628	10.27372	10.05420	10.32792	58
3	9.67232	9.94573	9.72659	10.27341	10.05427	10.32768	57
4	9.67256	9.94567	9.72689	10.27311	10.05433	10.32744	56
5	9.67280	9.94560	9.72720	10.27280	10.05440	10.32721	55
6	9.67303	9.94553	9.72750	10.27250	10.05447	10.32697	54
7	9.67327	9.94546	9.72781	10.27220	10.05454	10.32673	53
8	9.67351	9.94540	9.72811	10.27189	10.05460	10.32650	52
9	9.67374	9.94533	9.72841	10.27159	10.05467	10.32626	51
10	9.67398	9.94526	9.72872	10.27128	10.05474	10.32602	50
11	9.67421	9.94519	9.72902	10.27098	10.05481	10.32579	49
12	9.67445	9.94513	9.72932	10.27068	10.05487	10.32555	48
13	9.67468	9.94506	9.72963	10.27037	10.05494	10.32532	47
14	9.67492	9.94499	9.72993	10.27007	10.05501	10.32508	46
15	9.67516	9.94492	9.73023	10.26977	10.05508	10.32485	45
16	9.67539	9.94485	9.73054	10.26947	10.05515	10.32461	44
17	9.67562	9.94479	9.73084	10.26916	10.05521	10.32438	43
18	9.67586	9.94472	9.73114	10.26886	10.05528	10.32414	42
19	9.67609	9.94465	9.73144	10.26856	10.05535	10.32391	41
20	9.67633	9.94458	9.73175	10.26825	10.05542	10.32367	40
21	9.67656	9.94451	9.73205	10.26795	10.05549	10.32344	39
22	9.67680	9.94445	9.73235	10.26765	10.05555	10.32320	38
23	9.67703	9.94438	9.73265	10.26735	10.05562	10.32297	37
24	9.67726	9.94431	9.73296	10.26705	10.05569	10.32274	36
25	9.67750	9.94424	9.73326	10.26674	10.05576	10.32250	35
26	9.67773	9.94417	9.73356	10.26644	10.05583	10.32227	34
27	9.67796	9.94410	9.73386	10.26614	10.05590	10.32204	33
28	9.67820	9.94404	9.73416	10.26584	10.05596	10.32180	32
29	9.67843	9.94397	9.73446	10.26554	10.05603	10.32157	31
30	9.67866	9.94390	9.73476	10.26524	10.05610	10.32134	30
		Sine.		Tang.		Secant.	Min.

61 *Degrees.*

Tangents, and Secants.

28 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.67866	9.94390	9.73476	10.26524	10.05610	10.32134	30
31	9.67890	9.94383	9.73507	10.26493	10.05617	10.32110	29
32	9.67913	9.94376	9.73537	10.26463	10.05624	10.32087	28
33	9.67936	9.94369	9.73567	10.26433	10.05631	10.32064	27
34	9.67959	9.94362	9.73597	10.26403	10.05638	10.32041	26
35	9.67982	9.94356	9.73627	10.26373	10.05645	10.32018	25
36	9.68006	9.94349	9.73657	10.26343	10.05651	10.31994	24
37	9.68029	9.94342	9.73687	10.26313	10.05658	10.31971	23
38	9.68052	9.94335	9.73717	10.26283	10.05665	10.31948	22
39	9.68075	9.94328	9.73747	10.26253	10.05672	10.31925	21
40	9.68098	9.94321	9.73777	10.26223	10.05679	10.31902	20
41	9.68121	9.94314	9.73807	10.26193	10.05686	10.31879	19
42	9.68144	9.94307	9.73837	10.26163	10.05693	10.31856	18
43	9.68167	9.94300	9.73867	10.26133	10.05700	10.31833	17
44	9.68191	9.94293	9.73897	10.26103	10.05707	10.31810	16
45	9.68214	9.94286	9.73927	10.26073	10.05714	10.31787	15
46	9.68237	9.94280	9.73957	10.26043	10.05721	10.31763	14
47	9.68260	9.94273	9.73987	10.26013	10.05727	10.31741	13
48	9.68283	9.94266	9.74017	10.25983	10.05734	10.31718	12
49	9.68306	9.94259	9.74047	10.25953	10.05741	10.31695	11
50	9.68328	9.94252	9.74077	10.25923	10.05748	10.31672	10
51	9.68351	9.94245	9.74107	10.25893	10.05755	10.31649	9
52	9.68374	9.94238	9.74137	10.25864	10.05762	10.31626	8
53	9.68397	9.94231	9.74106	10.25834	10.05769	10.31603	7
54	9.68420	9.94224	9.74196	10.25804	10.05776	10.31580	6
55	9.68443	9.94217	9.74226	10.25774	10.05783	10.31557	5
56	9.68466	9.94210	9.74256	10.25744	10.05790	10.31534	4
57	9.68489	9.94203	9.74286	10.25714	10.05797	10.31511	3
58	9.68512	9.94196	9.74316	10.25684	10.05804	10.31489	2
59	9.68534	9.94189	9.74345	10.25655	10.05811	10.31466	1
60	9.68557	9.94182	9.74375	10.25625	10.05818	10.31443	0
		Sine.		Tang.		Secant.	Min.

61 *Degrees.*

A Table of Artificial Sines,

29 Degrees.

Min.	Sine.		Tang.		Secant.		
0	9.68557	9.94182	9.74375	10.25625	10.05818	10.31443	60
1	9.68580	9.94175	9.74405	10.25595	10.05825	10.31420	59
2	9.68603	9.94168	9.74435	10.25565	10.05832	10.31397	58
3	9.68625	9.94161	9.74465	10.25536	10.05839	10.31375	57
4	9.68648	9.94154	9.74494	10.25506	10.05846	10.31352	56
5	9.68671	9.94147	9.74524	10.25476	10.05853	10.31329	55
6	9.68694	9.94140	9.74554	10.25446	10.05860	10.31306	54
7	9.68716	9.94133	9.74584	10.25417	10.05867	10.31284	53
8	9.68739	9.94126	9.74613	10.25387	10.05874	10.31261	52
9	9.68762	9.94119	9.74643	10.25357	10.05881	10.31238	51
10	9.68784	9.94112	9.74673	10.25327	10.05888	10.31216	50
11	9.68807	9.94105	9.74702	10.25298	10.05895	10.31193	49
12	9.68830	9.94098	9.74732	10.25268	10.05902	10.31171	48
13	9.68852	9.94091	9.74762	10.25238	10.05910	10.31148	47
14	9.68875	9.94083	9.74791	10.25209	10.05917	10.31125	46
15	9.68897	9.94076	9.74821	10.25179	10.05924	10.31103	45
16	9.68920	9.94069	9.74851	10.25150	10.05931	10.31080	44
17	9.68942	9.94062	9.74880	10.25120	10.05938	10.31058	43
18	9.68965	9.94055	9.74910	10.25090	10.05945	10.31035	42
19	9.68987	9.94048	9.74939	10.25061	10.05952	10.31013	41
20	9.69010	9.94041	9.74969	10.25031	10.05959	10.30990	40
21	9.69032	9.94034	9.74997	10.25002	10.05966	10.30968	39
22	9.69055	9.94027	9.75028	10.24972	10.05973	10.30945	38
23	9.69077	9.94020	9.75058	10.24942	10.05980	10.30923	37
24	9.69100	9.94013	9.75087	10.24913	10.05988	10.30900	36
25	9.66122	9.94005	9.75117	10.24883	10.05995	10.30878	35
26	9.69144	9.93998	9.75146	10.24854	10.06002	10.30856	34
27	9.69167	9.93991	9.75176	10.24824	10.06009	10.30833	33
28	9.69190	9.93984	9.75205	10.24795	10.06016	10.30811	32
29	9.69212	9.93977	9.75235	10.24765	10.06023	10.30788	31
30	9.69234	9.93970	9.75264	10.24736	10.06030	10.30766	30
		Sine.		Tang.		Secant.	Min.

60 Degrees.

Tangents, and Secants.

29 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.69234	9.93970	9.75264	10.24736	10.06030	10.30766	30
31	9.69256	9.93963	9.75294	10.24706	10.06038	10.30735	29
32	9.69279	9.93955	9.75323	10.24677	10.06045	10.30722	28
33	9.69301	9.93948	9.75353	10.24647	10.06052	10.30699	27
34	9.69323	9.93941	9.75382	10.24618	10.06059	10.30677	26
35	9.69345	9.93934	9.75413	10.24589	10.06066	10.30655	25
36	9.69368	9.93927	9.75441	10.24559	10.06073	10.30632	24
37	9.69390	9.93919	9.75470	10.24530	10.06081	10.30610	23
38	9.69412	9.93912	9.75500	10.24500	10.06088	10.30589	22
39	9.69434	9.93905	9.75529	10.24471	10.06095	10.30566	21
40	9.69456	9.93898	9.75559	10.24442	10.06102	10.30544	20
41	9.69479	9.93891	9.75588	10.24412	10.06109	10.30521	19
42	9.69501	9.93884	9.75617	10.24383	10.06116	10.30499	18
43	9.69523	9.93876	9.75647	10.24354	10.06124	10.30477	17
44	9.69545	9.93869	9.75676	10.24324	10.06131	10.30455	16
45	9.69567	9.93862	9.75705	10.24295	10.06138	10.30433	15
46	9.69589	9.93855	9.75735	10.24266	10.06145	10.30411	14
47	9.69611	9.93848	9.75764	10.24236	10.06153	10.30389	13
48	9.69633	9.93840	9.75793	10.24207	10.06160	10.30367	12
49	9.69655	9.93832	9.75822	10.24178	10.06167	10.30345	11
50	9.69677	9.93826	9.75852	10.24148	10.06174	10.30323	10
51	9.69700	9.93819	9.75881	10.24119	10.06182	10.30301	9
52	9.69722	9.93811	9.75910	10.24090	10.06189	10.30279	8
53	9.69744	9.93804	9.75940	10.24061	10.06196	10.30257	7
54	9.69765	9.93797	9.75969	10.24031	10.06203	10.30235	6
55	9.69787	9.93790	9.75998	10.24002	10.06211	10.30213	5
56	9.69809	9.93782	9.76027	10.23973	10.06218	10.30191	4
57	9.69831	9.93775	9.76056	10.23944	10.06225	10.30169	3
58	9.69853	9.93768	9.76086	10.23914	10.06232	10.30147	2
59	9.69875	9.93760	9.76115	10.23885	01.06240	10.30125	1
60	9.69897	9.93753	9.76144	10.23856	01.06247	10.30103	0
		Sine.		Tang.		Secant.	Min.

60 *Degrees.*

A Table of Artificial Sines,

30 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.69897	9.93753	9.76144	10.23856	10.06247	10.30103	60
1	9.69919	9.93746	9.76173	10.23827	10.06254	10.30081	59
2	9.69941	9.93739	9.76202	10.23798	10.06262	10.30059	58
3	9.69963	9.93731	9.76231	10.23769	10.06269	10.30037	57
4	9.69984	9.93724	9.76261	10.23739	10.06276	10.30016	56
5	9.70006	9.93717	9.76290	10.23710	10.06284	10.29994	55
6	9.70028	9.93709	9.76319	10.23681	10.06291	10.29972	54
7	9.70050	9.93702	9.76348	10.23652	10.06298	10.29950	53
8	9.70072	9.93695	9.76377	10.23623	10.06305	10.29928	52
9	9.70093	9.93687	9.76406	10.23594	10.06313	10.29907	51
10	9.70115	9.93680	9.76435	10.23565	10.06320	10.29885	50
11	9.70137	9.93673	9.76464	10.23536	10.06328	10.29863	49
12	9.70159	9.93665	9.76493	10.23507	10.06335	10.29842	48
13	9.70180	9.93658	9.76522	10.23478	10.06342	10.29820	47
14	9.70202	9.93651	9.76551	10.23449	10.06350	10.29798	46
15	9.70224	9.93643	9.76581	10.23420	10.06357	10.29776	45
16	9.70245	9.93636	9.76610	10.23391	10.06364	10.29755	44
17	9.70267	9.93628	9.76639	10.23362	10.06372	10.29733	43
18	9.70289	9.93621	9.76668	10.23333	10.06379	10.29712	42
19	9.70310	9.93614	9.76697	10.23304	10.06386	10.29690	41
20	9.70332	9.93606	9.76726	10.23275	10.06394	10.29668	40
21	9.70353	9.93599	9.76755	10.23246	10.06401	10.29647	39
22	9.70 75	9.93591	9.76783	10.23217	10.06409	10.29625	38
23	9.70396	9.93584	9.76812	10.23188	10.06416	10.29604	37
24	9.70413	9.93577	9.76841	10.23159	10.06423	10.29582	36
25	9.70440	9.93569	9.76870	10.23130	10.06431	10.29561	35
26	9.70461	9.93562	9.76899	10.23101	10.06438	10.29539	34
27	9.70483	9.93554	9.76928	10.23072	10.06446	10.29518	33
28	9.70504	9.93547	9.76957	10.23043	10.06453	10.29496	32
29	9.70525	9.93540	9.76986	10.23014	10.06461	10.29475	31
30	9.70547	9.93532	9.77015	10.22985	10.06468	1[illegible].29453	30
		Sine.		Tang.		Secant.	Min.

59 *Degrees.*

Tangents, and Secants.

30 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.70547	9.93532	9.77015	10.22985	10.06468	10.29453	30
31	9.70568	9.93525	9.77044	10.22956	10.06475	10.29432	29
32	9.70590	9.93517	9.77073	10.22927	10.06483	10.29410	28
33	9.70611	9.93510	9.77102	10.22899	10.06490	10.29389	27
34	9.70633	9.93502	9.77130	10.22870	10.06498	10.29367	26
35	9.70654	9.93495	9.77159	10.22841	10.06505	10.29346	25
36	9.70675	9.93487	9.77188	10.22812	10.06513	10.29325	24
37	9.70697	9.93480	9.77217	10.22783	10.06520	10.29303	23
38	9.70718	9.93472	9.77246	10.22754	10.06528	10.29282	22
39	9.70739	9.93465	9.77275	10.22726	10.06535	10.29261	21
40	9.70761	9.93457	9.77303	10.22697	10.06543	10.29239	20
41	9.70782	9.93450	9.77332	10.22668	10.06550	10.29218	19
42	9.70803	9.93442	9.77361	10.22639	10.06558	10.29197	18
43	9.70825	9.93435	9.77390	10.22610	10.06565	10.29175	17
44	9.70846	9.93427	9.77418	10.22582	10.0657	10.29154	16
45	9.70867	9.93420	9.77447	10.22553	10.06580	10.29133	15
46	9.70888	9.93412	9.77476	10.22524	10.06588	10.29112	14
47	9.70909	9.93405	9.77505	10.22495	10.06595	10.29091	13
48	9.70931	9.93397	9.77533	10.22467	10.06603	10.29069	12
49	9.70952	9.93390	9.77562	10.22438	10.06610	10.29048	11
50	9.70973	9.93382	9.77591	10.22409	10.06618	10.29027	10
51	9.70994	9.93375	9.77620	10.22381	10.06625	10.29006	9
52	9.71015	9.93367	9.77648	10.22352	10.06633	10.28985	8
53	9.71036	9.93360	9.77677	10.22323	10.06640	10.28964	7
54	9.71058	9.93352	9.77706	10.22295	10.06648	10.28943	6
55	9.71079	9.93344	9.77734	10.22266	10.06656	10.28921	5
56	9.71100	9.93337	9.77763	10.22237	10.06663	10.28900	4
57	9.71121	9.93329	9.77792	10.22209	10.06671	10.28879	3
58	9.71142	9.93322	9.77820	10.22180	10.06678	10.28858	2
59	9.71163	9.93314	9.77849	10.22151	10.06686	10.28837	1
60	9.71184	9.93307	9.77877	10.22123	10.06693	10.28816	0
		Sine.		Tang.		Secant.	Min.

59 *Degrees.*

A Table of Artificial Sines,

31 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.71184	9.93307	9.77877	10.22123	10.06693	10.28816	60
1	9.71205	9.93299	9.77906	10.22094	10.06701	10.28795	59
2	9.71226	9.93291	9.77935	10.22065	10.06709	10.28774	58
3	9.71247	9.93284	9.77963	10.22037	10.06716	10.28753	57
4	9.71268	9.93276	9.77992	10.22008	10.06727	10.28732	56
5	9.71289	9.93269	9.78020	10.21980	10.06732	10.28711	55
6	9.71310	9.93261	9.78049	10.21951	10.06739	10.28690	54
7	9.71331	9.93253	9.78078	10.21923	10.06747	10.28669	53
8	9.71352	9.93246	9.78106	10.21894	10.06754	10.28648	52
9	9.71373	9.93238	9.78135	10.21865	10.06762	10.28627	51
10	9.71394	9.93230	9.78163	10.21837	10.06770	10.28607	50
11	9.71414	9.93223	9.78192	10.21808	10.06777	10.28586	49
12	9.71435	9.93215	9.78220	10.21780	10.06785	10.28565	48
13	9.71456	9.93208	9.78249	10.21751	10.06793	10.28544	47
14	9.71477	9.93200	9.78277	10.21723	10.06800	10.28523	46
15	9.71498	9.93192	9.78306	10.21695	10.06808	10.28502	45
16	9.71519	9.93185	9.78334	10.21666	10.06816	10.28481	44
17	9.71539	9.93177	9.78363	10.21637	10.06823	10.28461	43
18	9.71560	9.93169	9.78391	10.21609	10.06831	10.28440	42
19	9.71581	9.93161	9.78419	10.21581	10.06839	10.28419	41
20	9.71602	9.93154	9.78448	10.21552	10.06846	10.28398	40
21	9.71622	9.93146	9.78479	10.21524	10.06854	10.28378	39
22	9.71643	9.93138	9.78505	10.21495	10.06862	10.28357	38
23	9.71664	9.93131	9.78533	10.21467	10.06869	10.28336	37
24	9.71685	9.93123	9.78562	10.21438	10.06877	10.28315	36
25	9.71705	9.93115	9.78590	10.21410	10.06885	10.28295	35
26	9.71726	9.93108	9.78618	10.21382	10.06893	10.28274	34
27	9.71747	9.93100	9.78647	10.21353	10.06900	10.28253	33
28	9.71767	9.93092	9.78675	10.21325	10.06908	10.28233	32
29	9.71788	9.93084	9.78704	10.21296	10.06916	10.28212	31
30	9.71809	9.93077	9.78732	10.21268	10.06923	10.28192	30
		Sine.		Tang.		Secant.	Min.

58 *Degrees.*

Tangents, and Secants.

31 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.71809	9.93077	9.78732	10.21268	10.06923	10.28192	30
31	9.71829	9.93069	9.78760	10.21240	10.06931	10.28171	29
32	9.71850	9.93061	9.78789	10.21211	10.06939	10.28150	28
33	9.71870	9.93053	9.78817	10.21183	10.06947	10.28130	27
34	9.71891	9.93046	9.78845	10.21155	10.06954	10.28109	26
35	9.71911	9.93038	9.78874	10.21126	10.06962	10.28089	25
36	9.71932	9.93030	9.78902	10.21098	10.06970	10.28068	24
37	9.71953	9.93022	9.78930	10.21070	10.06978	10.28048	23
38	9.71973	9.93015	9.78959	10.21042	10.06986	10.28027	22
39	9.71994	9.93007	9.78987	10.21013	10.06993	10.28007	21
40	9.72014	9.92999	9.79015	10.20985	10.07001	10.27986	20
41	9.72035	9.92991	9.79043	10.20957	10.07009	10.27966	19
42	9.72055	9.92983	9.79072	10.20928	10.07017	10.27945	18
43	9.72075	9.92976	9.79100	10.20900	10.07025	10.27925	17
44	9.72096	9.92968	9.79128	10.20872	10.07032	10.27904	16
45	9.72116	9.92960	9.79156	10.20844	10.07040	10.27884	15
46	9.72137	9.92952	9.79185	10.20815	10.07048	10.27863	14
47	9.72157	9.92944	9.79213	10.20787	10.07056	10.27843	13
48	9.72177	9.92936	9.79241	10.20759	10.07064	10.27823	12
49	9.72198	9.92929	9.79269	10.20731	10.07071	10.27802	11
50	9.72218	9.92[illegible]	9.79297	10.20703	10.07079	10.27782	10
51	9.72239	9.92913	9.79326	10.20674	10.07087	10.27762	9
52	9.72259	9.92905	9.79354	10.20646	10.07095	10.27741	8
53	9.72279	9.92897	9.79382	10.20618	10.07103	10.27721	7
54	9.72299	9.92889	9.79410	10.20590	10.07111	10.27701	6
55	9.72320	9.92881	9.79438	10.20562	10.07118	10.27681	5
56	9.72340	9.92874	9.79466	10.20534	10.07126	10.27660	4
57	9.72360	9.92866	9.79495	10.20505	10.07134	10.27640	3
58	9.72381	9.92858	9.79523	10.20477	10.07142	10.27620	2
59	9.72401	9.92850	9.79551	10.20449	10.07150	10.27599	1
60	9.72421	9.92842	9.79579	10.20421	10.07158	10.27579	0
		Sine.		Tang.		Secant.	Min.

58 *Degrees.*

A Table of Artificial Sines,

32 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.72421	9.92842	9.79579	10.20421	10.07158	10.27579	60
1	9.72441	9.92834	9.79607	10.20393	10.07166	10.27559	59
2	9.724[illegible]1	9.92826	9.79635	10.20365	10.07174	10.27539	58
3	9.72482	9.92818	9.79663	10.20337	10.07182	10.27518	57
4	9.72502	9.92810	9.79691	10.20309	10.07190	10.27498	56
5	9.72522	9.92803	9.79719	10.20281	10.07198	10.27478	55
6	9.72542	9.92795	9.79747	10.20253	10.07205	10.27458	54
7	9.72562	9.92787	9.79775	10.20225	10.07213	10.27438	53
8	9.72582	9.92779	9.79804	10.20196	10.07221	10.27418	52
9	9.72602	9.92770	9.79832	10.20168	10.07229	10.27398	51
10	9.72623	9.92763	9.79860	10.20140	10.07237	10.27378	50
11	9.72643	9.92755	9.79888	10.20112	10.07245	10.27357	49
12	9.72663	9.92747	9.79916	10.20084	10.07253	10.27337	48
13	9.72683	9.92739	9.79944	10.20056	10.07261	10.27317	47
14	9.72703	9.92731	9.79972	10.20028	10.07269	10.27297	46
15	9.72723	9.92723	9.80000	10.20000	10.07277	10.27277	45
16	9.72743	9.92715	9.80028	10.19972	10.07285	10.27257	44
17	9.72763	9.92707	9.80056	10.19944	10.07293	10.27237	43
18	9.72783	9.92699	9.80084	10.19916	10.07301	10.27217	42
19	9.72803	9.92691	9.80112	10.19888	10.07309	10.27197	41
20	9.72823	9.92683	9.80140	10.19860	10.07317	10.27177	40
21	9.72843	9.92675	9.80168	10.19833	10.07325	10.27157	39
22	9.72863	9.92667	9.80199	10.19805	10.07333	10.27137	38
23	7.72883	9.92659	9.80223	10.19777	10.07341	10.27118	37
24	9.72902	9.92651	9.80251	10.19749	10.07349	10.27098	36
25	9.72922	9.92643	9.80279	10.19721	10.07357	10.27078	35
26	9.72942	9.92635	9.80307	10.19693	10.07365	10.27058	34
27	9.72962	9.92627	9.80335	10.19665	10.07373	10.27038	33
28	9.72982	9.92619	9.80363	10.19637	10.07381	10.27018	32
29	9.73002	9.92611	9.80391	10.19609	10.07389	10.26998	31
30	9.73022	9.92603	9.80419	10.19581	10.07397	10.26978	30
		Sine.		Tang.		Secant.	Min.

57 *Degrees.*

Tangents, and Secants.

32 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.73022	9.92603	9.80419	10.19581	10.07397	10.26978	30
31	9.73042	9.92595	9.80447	10.19553	10.07405	10.26959	29
32	9.73061	9.92587	9.80475	10.19526	10.07413	10.26939	28
33	9.73081	9.92579	9.80502	10.19498	10.07421	10.26919	27
34	9.73101	9.92571	9.80530	10.19470	10.07429	10.26899	26
35	9.73121	9.92563	9.80558	10.19442	10.07437	10.26879	25
36	9.73140	9.92555	9.80586	10.19414	10.07446	10.26860	24
37	9.73160	9.92547	9.80614	10.19386	10.07454	10.26840	23
38	9.73180	9.92538	9.80642	10.19359	10.07462	10.26820	22
39	9.73200	9.92530	9.80669	10.19331	10.07470	10.26800	21
40	9.73219	9.92522	9.80697	10.19303	10.07478	10.26781	20
41	9.73239	9.92514	9.80725	10.19275	10.07486	10.26760	19
42	9.73259	9.92506	9.80753	10.19247	10.07494	10.26741	18
43	9.73278	9.92498	9.80781	10.19220	10.07502	10.26722	17
44	9.73298	9.92490	9.80808	10.19192	10.07510	10.26702	16
45	9.73318	9.92482	9.80836	10.19164	10.07518	10.26682	15
46	9.73337	9.92474	9.80864	10.19136	10.07527	10.26663	14
47	9.73357	9.92466	9.80892	10.19108	10.07534	10.26643	13
48	9.73377	9.92457	9.80919	10.19081	10.07543	10.26624	12
49	9.73396	9.92449	9.80947	10.19053	10.07551	10.26604	11
50	9.73416	9.92441	9.80975	10.19025	10.07559	10.26584	10
51	9.73435	9.92433	9.81003	10.18998	10.07567	10.26565	9
52	9.73455	9.92425	9.81030	10.18970	10.07575	10.26545	8
53	9.73474	9.92416	9.81058	10.18942	10.07584	10.26536	7
54	9.73494	9.92408	9.81086	10.18914	10.07592	10.26506	6
55	9.73513	9.92401	9.81113	10.18887	10.07600	10.26487	5
56	9.73533	9.92392	9.81141	10.18859	10.07608	10.26467	4
57	9.73553	9.92384	9.81169	10.18831	10.07616	10.26448	3
58	9.73572	9.92376	9.81196	10.18804	10.07625	10.26428	2
59	9.73591	9.92367	9.81224	10.18776	10.07633	10.26409	1
60	9.73611	9.92359	9.81252	10.18748	10.07641	10.26389	0
		Sine.		Tang.		Secant.	Min.

57 *Degrees.*

A Table of Artificial Sines,

33 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.73611	9.92359	9.81252	10.18748	10.07641	10.26389	60
1	9.73630	9.92351	9.81279	10.18721	10.07649	10.26370	59
2	9.73650	9.92343	9.81307	10.18693	10.07657	10.26350	58
3	9.73669	9.92335	9.81335	10.18665	10.07666	10.26331	57
4	9.73689	9.92326	9.81362	10.18638	10.07674	10.26311	56
5	9.73708	9.92318	9.81390	10.18610	10.07682	10.26292	55
6	9.73727	9.92310	9.81418	10.18582	10.07690	10.26273	54
7	9.73747	9.92302	9.81445	10.18555	10.07698	10.26253	53
8	9.73766	9.92293	9.81473	10.18527	10.07706	10.26234	52
9	9.73786	9.92285	9.81500	10.18500	10.07715	10.26215	51
10	9.73805	9.92277	9.81528	10.18472	10.07723	10.26195	50
11	9.73824	9.92269	9.81556	10.18445	10.07731	10.26176	49
12	9.73843	9.92260	9.81583	10.18417	10.07740	10.26157	48
13	9.73863	9.92252	9.81611	10.18389	10.07748	10.26137	47
14	9.73882	9.92244	9.81638	10.18362	10.07756	10.26118	46
15	9.73901	9.92236	9.81666	10.18334	10.07765	10.26099	45
16	9.73921	9.92227	9.81693	10.18307	10.07773	10.26079	44
17	9.73940	9.92219	9.81721	10.18279	10.07781	10.26060	43
18	9.73959	9.92211	9.81748	10.18252	10.07789	10.26041	42
19	9.73978	9.92202	9.81776	10.18224	10.07798	10.26022	41
20	9.73998	9.92194	9.81804	10.18197	10.07806	10.26003	40
21	9.74017	9.92186	9.81831	10.18169	10.07814	10.25983	39
22	9.74036	9.92177	9.81859	10.18142	10.07823	10.25964	38
23	9.74055	9.92169	9.81886	10.18114	10.07831	10.25945	37
24	9.74074	9.92161	9.81913	10.18087	10.07839	10.25926	36
25	9.74093	9.92152	9.81941	10.18059	10.07848	10.25907	35
26	9.74113	9.92144	9.81968	10.18032	10.07856	10.25888	34
27	9.74132	9.92136	9.81996	10.18004	10.07864	10.25868	33
28	9.74151	9.92127	9.82023	10.17977	10.07873	10.25849	32
29	9.74170	9.92119	9.82051	10.17949	10.07881	10.25830	31
30	9.74189	9.92111	9.82078	10.17922	10.07889	10.25811	30
		Sine.		Tang.		Secant.	Min.

56 *Degrees.*

Tangents, and Secants.

33 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.74189	9.92111	9.82078	10.17922	10.07889	10.25811	30
31	9.74208	9.92102	9.82106	10.17894	10.07898	10.25792	29
32	9.74227	9.92094	9.82133	10.17867	10.07906	10.25773	28
33	9.74246	9.92086	9.82161	10.17839	10.07914	10.25754	27
34	9.74265	9.92077	9.82188	10.17812	10.07923	10.25735	26
35	9.74284	9.92068	9.82215	10.17785	10.07931	10.25716	25
36	9.74303	9.92060	9.82243	10.17757	10.07940	10.25697	24
37	9.74322	9.92052	9.82270	10.17730	10.07948	10.25678	23
38	9.74341	9.92044	9.82298	10.17702	10.07956	10.25659	22
39	9.74360	9.92035	9.82325	10.17675	10.07965	10.25640	21
40	9.74379	9.92027	9.82352	10.17648	10.07973	10.25621	20
41	9.74398	9.92018	9.82380	10.17620	10.07982	10.25602	19
42	9.74417	9.92010	9.82407	10.17593	10.07990	10.25583	18
43	9.74436	9.92002	9.82435	10.17565	10.07999	10.25564	17
44	9.74455	9.91993	9.82462	10.17538	10.08007	10.25555	16
45	9.74474	9.91985	9.82489	10.17511	10.08015	10.25526	15
46	9.74493	9.91976	9.82517	10.17483	10.08024	10.25507	14
47	9.74512	9.91968	9.82544	10.17456	10.08032	10.25488	13
48	9.74531	9.91959	9.82571	10.17429	10.08041	10.25469	12
49	9.74549	9.91951	9.82599	10.17401	10.08049	10.25451	11
50	9.74568	9.91942	9.82626	10.17374	10.08058	10.25432	10
51	9.74587	9.91934	9.82653	10.17347	10.08066	10.25413	9
52	9.74606	9.91925	9.82681	10.17320	10.08075	10.25394	8
53	9.74625	9.91917	9.82708	10.17292	10.08083	10.25375	7
54	9.74644	9.91908	9.82735	10.17265	10.08092	10.25356	6
55	9.74662	9.91900	9.82762	10.17238	10.08100	10.25338	5
56	9.74681	9.91892	9.82790	10.17210	10.08109	10.25319	4
57	9.74700	9.91883	9.82817	10.17183	10.08117	10.25300	3
58	9.74719	9.91874	9.82844	10.17156	10.08126	10.25281	2
59	9.74737	9.91866	9.82872	10.17129	10.08134	10.25263	1
60	9.74756	9.91857	9.82899	10.17101	10.08143	10.25244	0
		Sine.		Tang.		Secant.	Min.

56 *Degrees.*

A Table of Artificial Sines,

34 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.74756	9.91857	9.82899	10.17101	10.08143	10.25244	60
1	9.74775	9.91849	9.82926	10.17074	10.08151	10.25225	59
2	9.74794	9.91840	9.82953	10.17047	10.08160	10.25206	58
3	9.74812	9.91832	9.82981	10.17020	10.08168	10.25188	57
4	9.74831	9.91823	9.83008	10.16992	10.08177	10.25169	56
5	9.74850	9.91815	9.83035	10.16965	10.08185	10.25150	55
6	9.74868	9.91806	9.83062	10.16938	10.08194	10.25132	54
7	9.74887	9.91798	9.83089	10.16911	10.08202	10.25113	53
8	9.74906	9.91789	9.83117	10.16884	10.08211	10.25094	52
9	9.74924	9.91781	9.83144	10.16856	10.08220	10.25076	51
10	9.74943	9.91772	9.83171	10.16829	10.08228	10.25057	50
11	9.74962	9.91763	9.83198	10.16802	10.08237	10.25039	49
12	9.74980	9.91755	9.83225	10.16775	10.08245	10.25020	48
13	9.74999	9.91746	9.83253	10.16748	10.08254	10.25001	47
14	9.75017	9.91738	9.83280	10.16720	10.08262	10.24983	46
15	9.75036	9.91729	9.83307	10.16693	10.08271	10.24964	45
16	9.75054	9.91720	9.83334	10.16666	10.08280	10.24946	44
17	9.75073	9.91712	9.83361	10.16639	10.08288	10.24927	43
18	9.75091	9.91703	9.83388	10.16612	10.08297	10.24909	42
19	9.75110	9.91695	9.83415	10.16585	10.08305	10.24890	41
20	9.75128	9.91686	9.83443	10.16558	10.08314	10.24872	40
21	9.75147	9.91677	9.83470	10.16530	10.08322	10.24853	39
22	9.75165	9.91669	9.83497	10.16503	10.08331	10.24835	38
23	9.75184	9.91660	9.83524	10.16476	10.08340	10.24816	37
24	9.75202	9.91651	9.83551	10.16449	10.08349	10.24798	36
25	9.75221	9.91643	9.83578	10.16422	10.08357	10.24779	35
26	9.75239	9.91634	9.83605	10.16395	10.08366	10.24761	34
27	9.75258	9.91625	9.83632	10.16368	10.08375	10.24742	33
28	9.75276	9.91617	9.83659	10.16341	10.08383	10.24724	32
29	9.75294	9.91608	9.83686	10.16314	10.08392	10.24706	31
30	9.75313	9.91599	9.83713	10.16287	10.08401	10.24687	30
		Sine.		Tang.		Secant.	Min.

55 *Degrees.*

Tangents, and Secants.

34 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.75313	9.91599	9.83713	10.16287	10.08401	10.24687	30
31	9.75331	9.91591	9.83741	10.16260	10.08409	10.24669	29
32	9.75350	9.91582	9.83768	10.16232	10.08418	10.24651	28
33	9.75368	9.91573	9.83795	10.16205	10.08427	10.24632	27
34	9.75386	9.91565	9.83822	10.16178	10.08435	10.24614	26
35	9.75405	9.91556	9.83849	10.16151	10.08444	10.24595	25
36	9.75423	9.91547	9.83876	10.16124	10.08453	10.24577	24
37	9.75441	9.91539	9.83903	10.16097	10.08462	10.24559	23
38	9.75460	9.91530	9.83930	10.16070	10.08470	10.24541	22
39	9.75478	9.91521	9.83957	10.16043	10.08479	10.24522	21
40	9.75496	9.91512	9.83984	10.16016	10.08488	10.24504	20
41	9.75514	9.91504	9.84011	10.15989	10.08497	10.24486	19
42	9.75533	9.91495	9.84038	10.15962	10.08505	10.24467	18
43	9.75551	9.91486	9.84065	10.15935	10.08514	10.24449	17
44	9.75569	9.91477	9.84092	10.15908	10.08523	10.24431	16
45	9.75587	9.91469	9.84119	10.15881	10.08532	10.24413	15
46	9.75605	9.91460	9.84146	10.15854	10.08540	10.24394	14
47	9.75624	9.91451	9.84173	10.15827	10.08549	10.24376	13
48	9.75642	9.91442	9.84200	10.15800	10.08558	10.24358	12
49	9.75660	9.91433	9.84227	10.15773	10.08567	10.24340	11
50	9.75678	9.91425	9.84254	10.15747	10.08575	10.24322	10
51	9.75696	9.91416	9.84281	10.15720	10.08584	10.24304	9
52	9.75714	9.91407	9.84307	10.15693	10.08593	10.24286	8
53	9.75733	9.91398	9.84334	10.15666	10.08602	10.24267	7
54	9.75751	9.91389	9.84361	10.15639	10.08611	10.24249	6
55	9.75769	9.91381	9.84388	10.15612	10.08619	10.24231	5
56	9.75787	9.91372	9.84415	10.15585	10.08628	10.24213	4
57	9.75805	9.91363	9.84442	10.15558	10.08637	10.24195	3
58	9.75823	9.91354	9.84469	10.15531	10.08646	10.24177	2
59	9.75841	9.91345	9.84496	10.15504	10.08655	10.24159	1
60	9.75859	9.91336	9.84523	10.15477	10.08664	10.24141	0
		Sine.		Tang.		Secant.	Min.

55 *Degrees.*

A Table of Artificial Sines,

35 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.75859	9.91336	9.84523	10.15477	10.08664	10.24141	60
1	9.75877	9.91328	9.84550	10.15450	10.08672	10.24123	59
2	9.75895	9.91319	9.84576	10.15424	10.08681	10.24105	58
3	9.75913	9.91310	9.84603	10.15397	10.08690	10.24087	57
4	9.75931	9.91301	9.84630	10.15370	10.08699	10.24069	56
5	9.75949	9.91292	9.84657	10.15343	10.08708	10.24051	55
6	9.75967	9.91283	9.84684	10.15316	10.08717	10.24033	54
7	9.75985	9.91274	9.84711	10.15289	10.08726	10.24015	53
8	9.76003	9.91266	9.84738	10.15262	10.08735	10.23997	52
9	9.76021	9.91257	9.84764	10.15236	10.08743	10.23979	51
10	9.76039	9.91248	9.84791	10.15209	10.08752	10.23961	50
11	9.76057	9.91239	9.84818	10.15182	10.08761	10.23943	49
12	9.76075	9.91230	9.84845	10.15155	10.08770	10.23925	48
13	9.76093	9.91221	9.84872	10.15128	10.08779	10.23907	47
14	9.76111	9.91212	9.84899	10.15101	10.08788	10.23889	46
15	9.76129	9.91203	9.84925	10.15075	10.08797	10.23872	45
16	9.76146	9.91194	9.84952	10.15048	10.08806	10.23854	44
17	9.76164	9.91185	9.84979	10.15021	10.08815	10.23836	43
18	9.76182	9.91176	9.85006	10.14994	10.08824	10.23818	42
19	9.76200	9.91167	9.85033	10.14968	10.08833	10.23800	41
20	9.76218	9.91158	9.85059	10.14941	10.08842	10.23782	40
21	9.76236	9.91150	9.85086	10.14914	10.08851	10.23764	39
22	9.76253	9.91141	9.85113	10.14887	10.08860	10.23747	38
23	9.76271	9.91132	9.85140	10.14860	10.08868	10.23729	37
24	9.76289	9.91123	9.85166	10.14834	10.08877	10.23711	36
25	9.76307	9.91114	9.85193	10.14807	10.08886	10.23693	35
26	9.76325	9.91105	9.85220	10.14780	10.08895	10.23676	34
27	9.76342	9.91096	9.85247	10.14753	10.08904	10.23658	33
28	9.76360	9.91087	9.85273	10.14727	10.08913	10.23640	32
29	9.76378	9.91078	9.85300	10.14700	10.08922	10.23622	31
30	9.76395	9.91069	9.85327	10.14673	10.08931	10.23605	30
		Sine.		Tang.		Secant.	Min.

54 *Degrees.*

Tangents, and Secants.

35 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.76395	9.91069	9.85327	10.14673	10.08931	10.23605	30
31	9.76413	9.91060	9.85354	10.14647	10.08940	10.23587	29
32	9.76431	9.91051	9.85380	10.14620	10.08949	10.23569	28
33	9.76449	9.91042	9.85407	10.14593	10.08959	10.23552	27
34	9.76466	9.91033	9.85434	10.14566	10.08968	10.23534	26
35	9.76484	9.91024	9.85460	10.14540	10.08977	10.23516	25
36	9.76502	9.91014	9.85487	10.14513	10.08986	10.23499	24
37	9.76519	9.91005	9.85514	10.14486	10.08995	10.23481	23
38	9.76537	9.90996	9.85540	10.14460	10.09004	10.23463	22
39	9.76554	9.90987	9.85567	10.14433	10.09013	10.23446	21
40	9.76572	9.90978	9.85594	10.14406	10.09022	10.23428	20
41	9.76590	9.90969	9.85620	10.14380	10.09031	10.23410	19
42	9.76607	9.90960	9.85647	10.14353	10.09040	10.23393	18
43	9.76625	9.90951	9.85674	10.14326	10.09049	10.23375	17
44	9.76642	9.90942	9.85700	10.14300	10.09058	10.23358	16
45	9.76660	9.90933	9.85727	10.14273	10.09067	10.23340	15
46	9.76677	9.90924	9.85754	10.14246	10.09076	10.23323	14
47	9.76695	9.90915	9.85780	10.14220	10.09085	10.23305	13
48	9.76712	9.90906	9.85807	10.14183	10.09095	10.23288	12
49	9.76729	9.90896	9.85834	10.14166	10.09104	10.23270	11
50	9.76748	9.90887	9.85860	10.14140	10.09113	10.23253	10
51	9.76765	9.90878	9.85887	10.14113	10.09122	10.23235	9
52	9.76782	9.90869	9.85913	10.14097	10.09131	10.23218	8
53	9.76800	9.90860	9.85940	10.14060	10.09140	10.23200	7
54	9.76817	9.90851	9.85967	10.14033	10.09149	10.23183	6
55	9.76835	9.90842	9.85993	10.14007	10.09158	10.23165	5
56	9.76852	9.90832	9.86020	10.13980	10.09168	10.23148	4
57	9.76870	9.90823	9.86046	10.13954	10.09177	10.23130	3
58	9.76887	9.90814	9.86073	10.13927	10.09186	10.23113	2
59	9.76904	9.90805	9.86100	10.13901	10.09195	10.23096	1
60	9.76922	9.90796	9.86126	10.13874	10.09204	10.23078	0
		Sine.		Tang.		Secant.	Min.

54 *Degrees.*

A Table of Artificial Sines,

36 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.76922	9.90796	9.86126	10.13874	10.09204	10.23078	60
1	9.76939	9.90787	9.86153	10.13847	10.09213	10.23061	59
2	9.76957	9.90777	9.86179	10.13821	10.09223	10.23043	58
3	9.76974	9.90768	9.86206	10.13794	10.09232	10.23026	57
4	9.76991	9.90759	9.86232	10.13768	10.09241	10.23009	56
5	9.77009	9.90750	9.86259	10.13741	10.09250	10.22991	55
6	9.77026	9.90741	9.86285	10.13715	10.09259	10.22974	54
7	9.77043	9.90731	9.86312	10.13688	10.09269	10.22957	53
8	9.77061	9.90722	9.86339	10.13662	10.09278	10.22939	52
9	9.77078	9.90713	9.86365	10.13635	10.09287	10.22922	51
10	9.77095	9.90704	9.86[illegible]92	10.13609	10.09296	10.22905	50
11	9.77113	9.90695	9.86418	10.13582	10.09306	10.22888	49
12	9.77130	9.90685	9.86445	10.13556	10.09315	10.22870	48
13	9.77147	9.90676	9.86471	10.13529	10.09324	10.22852	47
14	9.77164	9.90667	9.86498	10.13502	10.09333	10.22836	46
15	9.77182	9.90657	9.86524	10.13476	10.09343	10.22819	45
16	9.77199	9.90648	9.86551	10.13450	10.09352	10.22801	44
17	9.77216	9.90639	9.86577	10.13423	10.09361	10.22784	43
18	9.77233	9.90630	9.86604	10.13397	10.09370	10.22767	42
19	9.77250	9.90620	9.86630	10.13370	10.09380	10.22750	41
20	9.77268	9.90611	9.86656	10.13344	10.09389	10.22733	40
21	9.77285	9.90602	9.86683	10.13317	10.09398	10.22715	39
22	9.77302	9.90593	9.86709	10.13291	10.09408	10.22698	38
23	9.77319	9.90583	9.86736	10.13264	10.09417	10.22681	37
24	9.77336	9.90574	9.86[illegible]62	10.13238	10.09426	10.22664	36
25	9.77353	9.905[illegible]5	9.86789	10.13211	10.09436	10.22647	35
26	9.77370	9.90555	9.86815	10.13185	10.09445	10.22630	34
27	9.77388	9.90546	9.86842	10.13158	10.09454	10.22613	33
28	9.77405	9.90537	9.86868	10.13132	10.09463	10.22595	32
29	9.77422	9.90527	9.86894	10.13106	10.09473	10.22578	31
30	9.77439	9.90518	9.86921	10.13079	10.09482	10.22561	30
		Sine.		Tang.		Secant.	Min.

53 *Degrees.*

Tangents, and Secants.

36 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.77439	9.90518	9.86921	10.13079	10.09482	10.22561	30
31	9.77456	9.90509	9.86947	10.13053	10.09491	10.22544	29
32	9.77473	9.90499	9.86974	10.13026	10.09501	10.22527	28
33	9.77490	9.90490	9.87000	10.13000	10.09510	10.22510	27
34	9.77507	9.90480	9.87027	10.12974	10.09520	10.22493	26
35	9.77524	9.90471	9.87053	10.12947	10.09529	10.22476	25
36	9.77541	9.90462	9.87079	10.12921	10.09538	10.22459	24
37	9.77558	9.90452	9.87106	10.12894	10.09548	10.22442	23
38	9.77575	9.90443	9.87132	10.12868	10.09557	10.22425	22
39	9.77592	9.90433	9.87159	10.12842	10.09567	10.22408	21
40	9.77609	9.90424	9.87185	10.12815	10.09576	10.22391	20
41	9.77626	9.90415	9.87211	10.12789	10.09585	10.22374	19
42	9.77643	9.90405	9.87238	10.12762	10.09595	10.22357	18
43	9.77660	9.90396	9.87264	10.12736	10.09604	10.22340	17
44	9.77677	9.90386	9.87290	10.12710	10.09614	10.22323	16
45	9.77694	9.90377	9.87317	10.12683	10.09623	10.22306	15
46	9.77711	9.90368	9.87343	10.12657	10.09632	10.22289	14
47	9.77728	9.90358	9.87369	10.12631	10.09642	10.22272	13
48	9.77744	9.90349	9.87396	10.12604	10.09651	10.22256	12
49	9.77761	9.90339	9.87422	10.12578	10.09661	10.22239	11
50	9.77778	9.90330	9.87448	10.12552	10.09670	10.22222	10
51	9.77795	9.90320	9.87475	10.12525	10.09680	10.22205	9
52	9.77812	9.90311	9.87501	10.12499	10.09689	10.22188	8
53	9.77829	9.90301	9.87527	10.12473	10.09699	10.22171	7
54	9.77846	9.90292	9.87554	10.12446	10.09708	10.22154	6
55	9.77862	9.90282	9.87580	10.12420	10.09718	10.22138	5
56	9.77879	9.90273	9.87606	10.12394	10.09727	10.22121	4
57	9.77896	9.90263	9.87633	10.12367	10.09737	10.22104	3
58	9.77913	9.90254	9.87659	10.12341	10.09746	10.22087	2
59	9.77930	9.90244	9.87685	10.12315	10.09756	10.22070	1
60	9.77946	9.90235	9.87711	10.12289	10.09765	10.22054	0
		Sine.		Tang.		Secant.	Min.

53 *Degrees.*

A Table of Artificial Sines,

37 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.77946	9.90235	9.87711	10.12289	10.09765	10.22054	60
1	9.77964	9.90225	9.87738	10.12262	10.09775	10.22037	59
2	9.77980	9.90216	9.87764	10.12236	10.09784	10.22020	58
3	9.77997	9.90206	9.87790	10.12210	10.09794	10.22003	57
4	9.78013	9.90197	9.87817	10.12184	10.09803	10.21987	56
5	9.78030	9.90187	9.87843	10.12157	10.09813	10.21970	55
6	9.78047	9.90178	9.87869	10.12131	10.09822	10.21953	54
7	9.78063	9.90168	9.87895	10.12105	10.09832	10.21937	53
8	9.78080	9.90159	9.87922	10.12078	10.09842	10.21920	52
9	9.78097	9.90149	9.87948	10.12052	10.09851	10.21903	51
10	9.78113	9.90139	9.87974	10.12026	10.09861	10.21887	50
11	9.78130	9.90130	9.88000	10.12000	10.09870	10.21870	49
12	9.78147	9.90120	9.88027	10.11974	10.09880	10.21853	48
13	9.78163	9.90111	9.88053	10.11947	10.09889	10.21837	47
14	9.78180	9.90101	9.88080	10.11921	10.09899	10.21810	46
15	9.78197	9.90091	9.88105	10.11895	10.09909	10.21803	45
16	9.78213	9.90082	9.88131	10.11869	10.09918	10.21787	44
17	9.78230	9.90072	9.88158	10.11842	10.09928	10.21770	43
18	9.78246	9.90063	9.88184	10.11816	10.09937	10.21754	42
19	9.78263	9.90053	9.88210	10.11790	10.09947	10.21737	41
20	9.78280	9.90043	9.88236	10.11764	10.09957	10.21720	40
21	9.78296	9.90034	9.88263	10.11738	10.09966	10.21704	39
22	9.78313	9.90024	9.88289	10.11711	10.09976	10.21687	38
23	9.78329	9.90014	9.88315	10.11685	10.09986	10.21671	37
24	9.78346	9.90005	9.88341	10.11659	10.09995	10.21654	36
25	9.78362	9.89995	9.88367	10.11633	10.10005	10.21638	35
26	9.78379	9.89985	9.88393	10.11607	10.10015	10.21621	34
27	9.78395	9.89976	9.88420	10.11580	10.10024	10.21605	33
28	9.78412	9.89966	9.88446	10.11554	10.10034	10.21588	32
29	9.78428	9.89956	9.88472	10.11528	10.10044	10.21572	31
30	9.78445	9.89947	9.88498	10.11502	10.10053	10.21555	30
		Sine.		Tang.		Secant.	Min.

52 *Degrees.*

Tangents, and Secants.

37 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.78445	9.89947	9.88498	10.11502	10.10053	10.21555	30
31	9.78461	9.89937	9.88524	10.11476	10.10063	10.21539	29
32	9.78478	9.89927	9.88550	10.11450	10.10073	10.21522	28
33	9.78494	9.89918	9.88577	10.11424	10.10082	10.21506	27
34	9.78511	9.89908	9.88603	10.11397	10.10092	10.21490	26
35	9.78527	9.89898	9.88629	10.11372	10.10102	10.21473	25
36	9.78543	9.89888	9.88655	10.11345	10.10112	10.21457	24
37	9.78560	9.89879	9.88681	10.11319	10.10121	10.21440	23
38	9.78576	9.89869	9.88707	10.11293	10.10131	10.21424	22
39	9.78593	9.89859	9.88733	10.11267	10.10141	10.21408	21
40	9.78609	9.89849	9.88759	10.11241	10.10151	10.21391	20
41	9.78625	9.89840	9.88786	10.11215	10.10160	10.21375	19
42	9.78642	9.89830	9.88812	10.11188	10.10170	10.21358	18
43	9.78658	9.89820	9.88838	10.11162	10.10180	10.21342	17
44	9.78674	9.89810	9.88864	10.11136	10.10190	10.21326	16
45	9.78691	9.89801	9.88890	10.11110	10.10199	10.21309	15
46	9.78707	9.89791	9.88916	10.11084	10.10209	10.21293	14
47	9.78723	9.89781	9.88942	10.11058	10.10219	10.21277	13
48	9.78740	9.89771	9.88968	10.11022	10.10229	10.21261	12
49	9.78756	9.89761	9.88994	10.11006	10.10239	10.21244	11
50	9.78772	9.89752	9.89020	10.10980	10.10248	10.21228	10
51	9.78788	9.89742	9.89047	10.10954	10.10258	10.21212	9
52	9.78805	9.89732	9.89073	10.10928	10.10268	10.21196	8
53	9.78821	9.89722	9.89099	10.10901	10.10278	10.21179	7
54	9.78837	9.89712	9.89125	10.10875	10.10288	10.21163	6
55	9.78853	9.89703	9.89151	10.10849	10.10298	10.21147	5
56	9.78869	9.89693	9.89177	10.10823	10.10307	10.21131	4
57	9.78886	9.89683	9.89203	10.10797	10.10317	10.21114	3
58	9.78902	9.89673	9.89229	10.10771	10.10327	10.21098	2
59	9.78918	9.89663	9.89255	10.10745	10.10337	10.21082	1
60	9.78934	9.89653	9.89281	10.10719	10.10347	10.21066	0
		Sine		Tang.		Secant.	Min.

52 *Degrees.*

A Table of Artificial Sines,

38 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.78934	9.89653	9.89281	10.10719	10.10347	10.21066	60
1	9.78950	9.89643	9.89307	10.10693	10.10357	10.21050	59
2	9.78967	9.89634	9.89333	10.10667	10.10366	10.21034	58
3	9.78983	9.89624	9.89359	10.10641	10.10376	10.21017	57
4	9.78999	9.89614	9.89385	10.10615	10.10386	10.21001	56
5	9.79015	9.89604	9.89411	10.10589	10.10396	10.20985	55
6	9.79031	9.89594	9.89437	10.10563	10.10406	10.20969	54
7	9.79047	9.89584	9.89463	10.10537	10.10416	10.20953	53
8	9.79063	9.89574	9.89489	10.10511	10.10426	10.20937	52
9	9.79079	9.89564	9.89515	10.10485	10.10436	10.20921	51
10	9.79095	9.89554	9.89541	10.10459	10.10446	10.20905	50
11	9.79112	9.89544	9.89567	10.10433	10.10456	10.20889	49
12	9.79128	9.89534	9.89593	10.10407	10.10466	10.20873	48
13	9.79144	9.89524	9.89619	10.10381	10.10476	10.20856	47
14	9.79160	9.89514	9.89645	10.10355	10.10486	10.20840	46
15	9.79176	9.89504	9.89671	10.10329	10.10496	10.20824	45
16	9.79192	9.89494	9.89697	10.10303	10.10506	10.20808	44
17	9.79208	9.89485	9.89723	10.10277	10.10515	10.20792	43
18	9.79224	9.89475	9.89749	10.10250	10.10525	10.20776	42
19	9.79240	9.89465	9.89775	10.10225	10.10535	10.20760	41
20	9.79256	9.89455	9.89801	10.10199	10.10545	10.20744	40
21	9.79272	9.89445	9.89827	10.10173	10.10555	10.20728	39
22	9.79288	9.89435	9.89853	10.10147	10.10565	10.20712	38
23	9.79304	9.89425	9.89879	10.10121	10.10575	10.20696	37
24	9.79320	9.89415	9.89905	10.10095	10.10585	10.20680	36
25	9.79335	9.89405	9.89931	10.10069	10.10595	10.20665	35
26	9.79351	9.89395	9.89957	10.10043	10.10605	10.20649	34
27	9.79367	9.89385	9.89983	10.10017	10.10615	10.20633	33
28	9.79383	9.89374	9.90009	10.09991	10.10626	10.20617	32
29	9.79399	9.89364	9.90035	10.09965	10.10636	10.20601	31
30	9.79415	9.89354	9.90061	10.09940	10.10646	10.20585	30
		Sine.		Tang.		Secant.	Min.

51 *Degrees.*

Tangents, and Secants.

38 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.79415	9.89354	9.90060	10.09939	10.10646	10.20585	30
31	9.79431	9.89344	9.90086	10.09914	10.10656	10.20569	29
32	9.79447	9.89334	9.90112	10.09888	10.10666	10.20553	28
33	9.79463	9.89324	9.90138	10.09862	10.10676	10.20537	27
34	9.79478	9.89314	9.90164	10.09836	10.10686	10.20522	26
35	9.79494	9.89304	9.90190	10.09810	10.10696	10.20506	25
36	9.79510	9.89294	9.90216	10.09784	10.10706	10.20490	24
37	9.79526	9.89284	9.90242	10.09758	10.10716	10.20474	23
38	9.79542	9.89274	9.90268	10.09732	10.10726	10.20458	22
39	9.79558	9.89264	9.90294	10.09706	10.10736	10.20442	21
40	9.79573	9.89254	9.90320	10.09680	10.10746	10.20427	20
41	9.79589	9.89244	9.90346	10.09654	10.10757	10.20411	19
42	9.79605	9.89233	9.90371	10.09629	10.10767	10.20395	18
43	9.79621	9.89223	9.90397	10.09603	10.10777	10.20379	17
44	9.79636	9.89213	9.90423	10.09577	10.10787	10.20364	16
45	9.79652	9.89203	9.90449	10.09551	10.10797	10.20348	15
46	9.79668	9.89193	9.90475	10.09525	10.10807	10.20332	14
47	9.79684	9.89183	9.90501	10.09499	10.10817	10.20316	13
48	9.79699	9.89173	9.90527	10.09473	10.10827	10.20301	12
49	9.79715	9.89162	9.90553	10.09447	10.10838	10.20285	11
50	9.79731	9.89152	9.90578	10.09422	10.10848	10.20269	10
51	9.79746	9.89142	9.90604	10.09396	10.10858	10.20254	9
52	9.79762	9.89132	9.90630	10.09370	10.10868	10.20238	8
53	9.79778	9.89122	9.90656	10.09344	10.10878	10.20222	7
54	9.79793	9.89112	9.90682	10.09318	10.10888	10.20207	6
55	9.79809	9.89101	9.90708	10.09292	10.10899	10.20191	5
56	9.79825	9.89091	9.90734	10.09266	10.10909	10.20175	4
57	9.79840	9.89081	9.90759	10.09241	10.10919	10.20160	3
58	9.79856	9.89071	9.90785	10.09215	10.10929	10.20144	2
59	9.79872	9.89061	9.90811	10.09189	10.10940	10.20128	1
60	9.79887	9.89050	9.90837	10.09163	10.10950	10.20113	0
		Sine.		Tang.		Secant.	Min.

51 *Degrees.*

A Table of Artificial Sines,

39 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.79887	9.89050	9.90837	10.09163	10.10950	10.20113	60
1	9.79903	9.89040	9.90863	10.09137	10.10960	10.20097	59
2	9.79918	9.89030	9.90889	10.09111	10.10970	10.20082	58
3	9.79934	9.89020	9.90914	10.09086	10.10981	10.20066	57
4	9.79950	9.89009	9.90940	10.09060	10.10991	10.20050	56
5	9.79965	9.88999	9.90966	10.09034	10.11001	10.20035	55
6	9.79981	9.88989	9.90992	10.09008	10.11011	10.20019	54
7	9.79996	9.88978	9.91018	10.08982	10.11022	10.20004	53
8	9.80012	9.88968	9.91043	10.08957	10.11032	10.19988	52
9	9.80027	9.88958	9.91069	10.08931	10.11042	10.19973	51
10	9.80043	9.88948	9.91095	10.08905	10.11052	10.19957	50
11	9.80058	9.88937	9.91121	10.08879	10.11063	10.19942	49
12	9.80074	9.88927	9.91147	10.08853	10.11073	10.19926	48
13	9.80089	9.88917	9.91172	10.08828	10.11083	10.19911	47
14	9.80105	9.88906	9.91198	10.08802	10.11094	10.19895	46
15	9.80120	9.88896	9.91224	10.08776	10.11104	10.19880	45
16	9.80136	9.88886	9.91250	10.08750	10.11114	10.19864	44
17	9.80151	9.88875	9.91276	10.08724	10.11125	10.19849	43
18	9.80166	9.88865	9.91301	10.08699	10.11135	10.19834	42
19	9.80182	9.88855	9.91327	10.08673	10.11145	10.19818	41
20	9.80197	9.88844	9.91353	10.08647	10.11156	10.19803	40
21	9.80213	9.88834	9.91379	10.08621	10.11166	10.19787	39
22	9.80228	9.88824	9.91404	10.08596	10.11176	10.19772	38
23	9.80244	9.88813	9.91430	10.08570	10.11187	10.19756	37
24	9.80259	9.88803	9.91456	10.08544	10.11197	10.19741	36
25	9.80274	9.88793	9.91482	10.08518	10.11207	10.19726	35
26	9.80290	9.88782	9.91507	10.08493	10.11218	10.19710	34
27	9.80305	9.88772	9.91533	10.08467	10.11228	10.19695	33
28	9.80320	9.88761	9.91559	10.08441	10.11239	10.19680	32
29	9.80336	9.88751	9.91585	10.08415	10.11249	10.19664	31
30	9.80351	9.88741	9.91610	10.08390	10.11259	10.19649	30
		Sine.		Tang.		Secant.	Min.

50 *Degrees.*

Tangents, and Secants.

39 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.80351	9.88741	9.91610	10.08390	10.11259	10.19649	30
31	9.80366	9.88730	9.91636	10.08364	10.11270	10.19634	29
32	9.80382	9.88720	9.91662	10.08338	10.11280	10.19618	28
33	9.80397	9.88709	9.91688	10.08312	10.11291	10.19603	27
34	9.80412	9.88699	9.91713	10.08287	10.11301	10.19588	26
35	9.80428	9.88688	9.91739	10.08261	10.11312	10.19572	25
36	9.80443	9.88678	9.91765	10.08235	10.11322	10.19557	24
37	9.80458	9.88668	9.91791	10.08209	10.11332	10.19542	23
38	9.80473	9.88657	9.91816	10.08184	10.11343	10.19527	22
39	9.80489	9.88647	9.91842	10.08158	10.11353	10.19511	21
40	9.80504	9.88636	9.91868	10.08132	10.11364	10.19496	20
41	9.80519	9.88626	9.91893	10.08107	10.11374	10.19481	19
42	9.80534	9.88615	9.91919	10.08081	10.11385	10.19466	18
43	9.80550	9.88605	9.91945	10.08055	10.11395	10.19450	17
44	9.80565	9.88594	9.91971	10.08029	10.11406	10.19435	16
45	9.80580	9.88584	9.91996	10.08004	10.11416	10.19420	15
46	9.80595	9.88573	9.92022	10.07978	10.11427	10.19405	14
47	9.80610	9.88563	9.92048	10.07952	10.11437	10.19390	13
48	9.80625	9.88552	9.92073	10.07927	10.11448	10.19375	12
49	9.80641	9.88542	9.92099	10.07901	10.11458	10.19359	11
50	9.80656	9.88531	9.92125	10.07875	10.11469	10.19344	10
51	9.80671	9.88521	9.92150	10.07850	10.11479	10.19329	9
52	9.80686	9.88510	9.92176	10.07824	10.11490	10.19314	8
53	9.80701	9.88499	9.92202	10.07798	10.11501	10.19299	7
54	9.80716	9.88489	9.92227	10.07773	10.11511	10.19284	6
55	9.80731	9.88478	9.92253	10.07747	10.11522	10.19269	5
56	9.80746	9.88468	9.92279	10.07721	10.11532	10.19254	4
57	9.80762	9.88457	9.92304	10.07696	10.11543	10.19238	3
58	9.80777	9.88447	9.92330	10.07670	10.11553	10.19223	2
59	9.80792	9.88436	9.92356	10.07644	10.11564	10.19208	1
60	9.80807	9.88425	9.92381	10.07619	10.11575	10.19193	0
		Sine.		Tang.		Secant.	Min.

50 *Degrees.*

A Table of Artificial Sines,

40 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.80807	9.88425	9.92381	10.07619	10.11575	10.19193	60
1	9.80822	9.88415	9.92407	10.07593	10.11585	10.19178	59
2	9.80837	9.88404	9.92433	10.07567	10.11596	10.19163	58
3	9.80852	9.88394	9.92458	10.07542	10.11606	10.19148	57
4	9.80867	9.88383	9.92484	10.07516	10.11617	10.19133	56
5	9.80882	9.88372	9.92510	10.07490	10.11628	10.19118	55
6	9.80897	9.88362	9.92535	10.07465	10.11638	10.19103	54
7	9.80912	9.88351	9.92561	10.07439	10.11649	10.19088	53
8	9.80927	9.88340	9.92587	10.07413	10.11660	10.19073	52
9	9.80942	9.88330	9.92612	10.07388	10.11670	10.19058	51
10	9.80957	9.88319	9.92638	10.07362	10.11681	10.19043	50
11	9.80972	9.88308	9.92663	10.07337	10.11692	10.19028	49
12	9.80987	9.88298	9.92689	10.07311	10.11702	10.19013	48
13	9.81002	9.88287	9.92715	10.07285	10.11713	10.18998	47
14	9.81017	9.88276	9.92740	10.07260	10.11724	10.18983	46
15	9.81032	9.88266	9.92766	10.07234	10.11734	10.18968	45
16	9.81047	9.88255	9.92792	10.07208	10.11745	10.18953	44
17	9.81061	9.88244	9.92817	10.07183	10.11756	10.18939	43
18	9.81076	9.88234	9.92843	10.07157	10.11766	10.18924	42
19	9.81091	9.88223	9.92868	10.07132	10.11777	10.18909	41
20	9.81106	9.88212	9.92894	10.07106	10.11788	10.18894	40
21	9.81121	9.88201	9.92920	10.07080	10.11799	10.18879	39
22	9.81136	9.88191	9.92945	10.07055	10.11809	10.18864	38
23	9.81151	9.88180	9.92971	10.07029	10.11820	10.18849	37
24	9.81166	9.88169	9.92996	10.07004	10.11381	10.18834	36
25	9.81180	9.88158	9.93022	10.06978	10.11842	10.18820	35
26	9.81195	9.88148	9.93048	10.06952	10.11852	10.18805	34
27	9.81210	9.88137	9.93073	10.06927	10.11863	10.18790	33
28	9.81225	9.88126	9.93099	10.06901	10.11874	10.18775	32
29	9.81240	9.88115	9.93124	10.06876	10.11885	10.18760	31
30	9.81254	9.88105	9.93150	10.06850	10.11895	10.18746	30
		Sine.		Tang.		Secant.	Min.

49 *Degrees.*

Tangents, and Secants.

40 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.81254	9.88105	9.93150	10.06850	10.11895	10.18746	30
31	9.81269	9.88094	9.93175	10.06825	10.11906	10.18731	29
32	9.81284	9.88083	9.93201	10.06799	10.11917	10.18716	28
33	9.81299	9.88072	9.93227	10.06773	10.11928	10.18701	27
34	9.81314	9.88061	9.93252	10.06748	10.11939	10.18686	26
35	9.81328	9.88050	9.93278	10.06722	10.11950	10.18672	25
36	9.81343	9.88040	9.93303	10.06697	10.11960	10.18657	24
37	9.81358	9.88029	9.93329	10.06671	10.11971	10.18642	23
38	9.81372	9.88018	9.93354	10.06646	10.11982	10.18628	22
39	9.81387	9.88007	9.93380	10.06620	10.11993	10.18613	21
40	9.81402	9.87996	9.93406	10.06594	10.12004	10.18598	20
41	9.81417	9.87986	9.93431	10.06569	10.12014	10.18583	19
42	9.81431	9.87975	9.93457	10.06543	10.12025	10.18569	18
43	9.81446	9.87964	9.93482	10.06518	10.12036	10.18554	17
44	9.81461	9.87953	9.93508	10.06492	10.12047	10.18539	16
45	9.81475	9.87942	9.93533	10.06467	10.12058	10.18525	15
46	9.81490	9.87931	9.93559	10.06441	10.12069	10.18510	14
47	9.81505	9.87920	9.93584	10.06416	10.12080	10.18495	13
48	9.81519	9.87909	9.93610	10.06390	10.12091	10.18481	12
49	9.81534	9.87898	9.93636	10.06364	10.12102	10.18466	11
50	9.81549	9.87888	9.93661	10.06339	10.12112	10.18451	10
51	9.81563	9.87877	9.93687	10.06313	10.12123	10.18437	9
52	9.81578	9.87866	9.93712	10.06288	10.12134	10.18422	8
53	9.81592	9.87855	9.93738	10.06262	10.12145	10.18408	7
54	9.81607	9.87844	9.93763	10.06237	10.12156	10.18393	6
55	9.81621	9.87833	9.93789	10.06211	10.12167	10.18379	5
56	9.81636	9.87822	9.93814	10.06186	10.12178	10.18364	4
57	9.81651	9.87811	9.93840	10.06160	10.12189	10.18349	3
58	9.81665	9.87800	9.93865	10.06135	10.12200	10.18335	2
59	9.81680	9.87789	9.93891	10.06109	10.12211	10.18320	1
60	9.81694	9.87778	9.93916	10.06084	10.12222	10.18306	0
		Sine.		Tang.		Secant.	Min.

49 *Degrees.*

A Table of Artificial Sines,

41 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.81694	9.87778	9.93916	10.06084	10.12222	10.18306	60
1	9.81709	9.87767	9.93942	10.06058	10.12233	10.18291	59
2	9.81723	9.87756	9.93967	10.06033	10.12244	10.18277	58
3	9.81738	9.87745	9.93993	10.06007	10.12255	10.18262	57
4	9.81752	9.87734	9.94018	10.05982	10.12266	10.18248	56
5	9.81767	9.87723	9.94044	10.05956	10.12277	10.18233	55
6	9.81781	9.87712	9.94069	10.05931	10.12288	10.18219	54
7	9.81796	9.87701	9.94095	10.05905	10.12299	10.18204	53
8	9.81810	9.87690	9.94120	10.05880	10.12310	10.18190	52
9	9.81825	9.87679	9.94146	10.05854	10.12321	10.18175	51
10	9.81839	9.87668	9.94171	10.05829	10.12332	10.18161	50
11	9.81854	9.87657	9.94197	10.05803	10.12343	10.18146	49
12	9.81868	9.87646	9.94222	10.05778	10.12354	10.18132	48
13	9.81883	9.87635	9.94248	10.05752	10.12365	10.18117	47
14	9.81897	9.87624	9.94273	10.05727	10.12376	10.18103	46
15	9.81911	9.87613	9.94299	10.05701	10.12387	10.18089	45
16	9.81926	9.87601	9.94324	10.05676	10.12399	10.18074	44
17	9.81940	9.87590	9.94350	10.05650	10.12410	10.18060	43
18	9.81955	9.87579	9.94375	10.05625	10.12421	10.18045	42
19	9.81969	9.87568	9.94401	10.05599	10.12432	10.18031	41
20	9.81983	9.87557	9.94426	10.05574	10.12443	10.18017	40
21	9.81998	9.87546	9.94452	10.05548	10.12454	10.18002	39
22	9.82012	9.87535	9.94477	10.05523	10.12465	10.17988	38
23	9.82026	9.87524	9.94503	10.05497	10.12476	10.17974	37
24	9.82041	9.87513	9.94528	10.05472	10.12487	10.17959	36
25	9.82055	9.87501	9.94554	10.05446	10.12499	10.17945	35
26	9.82069	9.87490	9.94579	10.05421	10.12510	10.17931	34
27	9.82084	9.87479	9.94604	10.05396	10.12521	10.17916	33
28	9.82098	9.87468	9.94630	10.05370	10.12532	10.17902	32
29	9.82112	9.87457	9.94655	10.05345	10.12543	10.17888	31
30	9.82126	9.87446	9.94681	10.05319	10.12554	10.17874	30
		Sine.		Tang.		Secant.	Min.

48 *Degrees.*

Tangents, and Secants.

41 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.82126	9.87446	9.94681	10.05319	10.12554	10.17874	30
31	9.82141	9.87434	9.94706	10.05294	10.12566	10.17859	29
32	9.82155	9.87423	9.94732	10.05268	10.12577	10.17845	28
33	9.82169	9.87412	9.94757	10.05243	10.12588	10.17831	27
34	9.82184	9.87401	9.94783	10.05217	10.12599	10.17816	26
35	9.82198	9.87390	9.94808	10.05192	10.12610	10.17802	25
36	9.82212	9.87378	9.94834	10.05166	10.12622	10.17788	24
37	9.82226	9.87367	9.94859	10.05141	10.12633	10.17774	23
38	9.82240	9.87356	9.94884	10.05116	10.12644	10.17760	22
39	9.82255	9.87345	9.94910	10.05090	10.12655	10.17745	21
40	9.82269	9.87334	9.94935	10.05065	10.12666	10.17731	20
41	9.82283	9.87322	9.94961	10.05039	10.12678	10.17717	19
42	9.82297	9.87311	9.94986	10.05014	10.12689	10.17703	18
43	9.82311	9.87300	9.95012	10.04988	10.12700	10.17689	17
44	9.82326	9.87288	9.95037	10.04963	10.12712	10.17674	16
45	9.82340	9.87277	9.95062	10.04938	10.12723	10.17660	15
46	9.82354	9.87266	9.95088	10.04912	10.12734	10.17646	14
47	9.82368	9.87255	9.95113	10.04887	10.12745	10.17632	13
48	9.82382	9.87243	9.95139	10.04861	10.12757	10.17618	12
49	9.82396	9.87232	9.95164	10.04836	10.12768	10.17604	11
50	9.82410	9.87221	9.95190	10.04810	10.12779	10.17590	10
51	9.82424	9.87209	9.95215	10.04785	10.12791	10.17576	9
52	9.82439	9.87198	9.95240	10.04760	10.12802	10.17561	8
53	9.82453	9.87187	9.95266	10.04734	10.12813	10.17547	7
54	9.82467	9.87175	9.95291	10.04709	10.12825	10.17533	6
55	9.82481	9.87164	9.95317	10.04683	10.12836	10.17519	5
56	9.82495	9.87153	9.95342	10.04658	10.12847	10.17505	4
57	9.82509	9.87141	9.95368	10.04632	10.12859	10.17491	3
58	9.82523	9.87130	9.95393	10.04607	10.12870	10.17477	2
59	9.82537	9.87119	9.95418	10.04582	10.12881	10.17463	1
60	9.82551	9.87107	9.95444	10.04556	10.12893	10.17449	0
		Sine.		Tang.		Secant.	Min.

48 *Degrees.*

A Table of Artificial Sines,

42 Degrees.

Min.	Sine.		Tang.		Secant.		
0	9.82551	9.87107	9.95444	10.04556	10.12893	10.17449	60
1	9.82565	9.87096	9.95469	10.04531	10.12904	10.17435	59
2	9.82579	9.87085	9.95495	10.04505	10.12915	10.17421	58
3	9.82593	9.87073	9.95520	10.04480	10.12927	10.17407	57
4	9.82607	9.87062	9.95545	10.04455	10.12938	10.17393	56
5	9.82621	9.87050	9.95571	10.04429	10.12950	10.17379	55
6	9.82635	9.87039	9.95596	10.04404	10.12961	10.17365	54
7	9.82649	9.87028	9.95622	10.04378	10.12972	10.17351	53
8	9.82663	9.87016	9.95647	10.04353	10.12984	10.17337	52
9	9.82677	9.87005	9.95672	10.04328	10.12995	10.17323	51
10	9.82691	9.86993	9.95698	10.04302	10.13007	10.17309	50
11	9.82705	9.86982	9.95723	10.04277	10.13018	10.17295	49
12	9.82719	9.86970	9.95749	10.04251	10.13030	10.17281	48
13	9.82733	9.86959	9.95774	10.04226	10.13041	10.17267	47
14	9.82747	9.86947	9.95799	10.04201	10.13053	10.17253	46
15	9.82761	9.86936	9.95825	10.04175	10.13064	10.17239	45
16	9.82774	9.86925	9.95850	10.04150	10.13075	10.17226	44
17	9.82788	9.86913	9.95875	10.04125	10.13087	10.17212	43
18	9.82802	9.86901	9.95901	10.04099	10.13099	10.17198	42
19	9.82816	9.86890	9.95926	10.04074	10.13110	10.17184	41
20	9.82830	9.86879	9.95952	10.04048	10.13121	10.17170	40
21	9.82844	9.86867	9.95977	10.04023	10.13133	10.17156	39
22	9.82858	9.86856	9.96002	10.03998	10.13144	10.17142	38
23	9.82872	9.86844	9.96028	10.03972	10.13156	10.17128	37
24	9.82886	9.86832	9.96053	10.03947	10.13168	10.17114	36
25	9.82899	9.86821	9.96078	10.03922	10.13179	10.17101	35
26	9.82913	9.86809	9.96104	10.03896	10.13191	10.17087	34
27	9.82927	9.86798	9.96129	10.03871	10.13202	10.17073	33
28	9.82941	9.86786	9.96155	10.03845	10.13214	10.17059	32
29	9.82954	9.86775	9.96180	10.03820	10.13225	10.17046	31
30	9.82968	9.86763	9.96205	10.03795	10.13237	10.17032	30
		Sine.		Tang.		Secant.	Min.

47 Degrees.

Tangents, and Secants.

42 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.82968	9.86763	9.96205	10.03795	10.13237	10.17032	30
31	9.82982	9.86752	9.96231	10.03769	10.13248	10.17018	29
32	9.82996	9.86740	9.96256	10.03744	10.13260	10.17004	28
33	9.83010	9.86728	9.96281	10.03719	10.13272	10.16990	27
34	9.83023	9.86717	9.96307	10.03693	10.13283	10.16977	26
35	9.83037	9.86705	9.96332	10.03668	10.13295	10.16963	25
36	9.83051	9.86694	9.96357	10.03643	10.13306	10.16949	24
37	9.83065	9.86682	9.96383	10.03617	10.13318	10.16935	23
38	9.83078	9.86670	9.96408	10.03592	10.13330	10.16922	22
39	9.83092	9.86659	9.96434	10.03566	10.13341	10.16908	21
40	9.83106	9.86647	9.96459	10.03541	10.13353	10.16894	20
41	9.83120	9.86635	9.96484	10.03516	10.13365	10.16880	19
42	9.83133	9.86624	9.96510	10.03490	10.13376	10.16867	18
43	9.83147	9.86612	9.96535	10.03465	10.13388	10.16852	17
44	9.83161	9.86600	9.96560	10.03440	10.13400	10.16839	16
45	9.83174	9.86589	9.96586	10.03414	10.13411	10.16826	15
46	9.83188	9.86577	9.96611	10.03389	10.13423	10.16812	14
47	9.83202	9.86565	9.96636	10.03364	10.13435	10.16798	13
48	9.83215	9.86554	9.96662	10.03338	10.13446	10.16785	12
49	9.83229	9.86542	9.96687	10.03313	10.13458	10.16771	11
50	9.83243	9.86530	9.96712	10.03288	10.13470	10.16757	10
51	9.83256	9.86519	9.96738	10.03262	10.13481	10.16744	9
52	9.83270	9.86507	9.96763	10.03237	10.13493	10.16730	8
53	9.83283	9.86495	9.96788	10.03212	10.13505	10.16717	7
54	9.83297	9.86483	9.96814	10.03186	10.13517	10.16703	6
55	9.83310	9.86472	9.96839	10.03161	10.13528	10.16690	5
56	9.83324	9.86460	9.96864	10.03136	10.13540	10.16676	4
57	9.83338	9.86448	9.96890	10.03110	10.13552	10.16662	3
58	9.83351	9.86436	9.96915	10.03085	10.13564	10.16649	2
59	9.83365	9.86425	9.96940	10.03060	10.13575	10.16635	1
60	9.83378	9.86413	9.96966	10.03034	10.13587	10.16622	0
		Sine.		Tang.		Secant.	Min.

47 *Degrees.*

A Table of Artificial Sines,

43 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.83378	9.86413	9.96966	10.03034	10.13587	10.16622	60
1	9.83392	9.86401	9.96991	10.03009	10.13599	10.16608	59
2	9.83405	9.86389	9.97016	10.02984	10.13611	10.16595	58
3	9.83419	9.86377	9.97042	10.02958	10.13623	10.16581	57
4	9.83432	9.86366	9.97067	10.02933	10.13634	10.16568	56
5	9.83446	9.86354	9.97092	10.02908	10.13646	10.16554	55
6	9.83460	9.86342	9.97118	10.02882	10.13658	10.16540	54
7	9.83473	9.86330	9.97143	10.02857	10.13670	10.16527	53
8	9.83487	9.86318	9.97168	10.02832	10.13682	10.16513	52
9	9.83500	9.86306	9.97194	10.02806	10.13694	10.16500	51
10	9.83513	9.86295	9.97219	10.02781	10.13705	10.16487	50
11	9.83527	9.86283	9.97244	10.02756	10.13717	10.16473	49
12	9.83540	9.86271	9.97269	10.02731	10.13729	10.16460	48
13	9.83554	9.86259	9.97295	10.02705	10.13741	10.16446	47
14	9.83567	9.86247	9.97320	10.02680	10.13753	10.16433	46
15	9.83581	9.86235	9.97345	10.02655	10.13765	10.16419	45
16	9.83594	9.86223	9.97371	10.02629	10.13777	10.16406	44
17	9.83608	9.86212	9.97396	10.02604	10.13788	10.16393	43
18	9.83621	9.86200	9.97421	10.02579	10.13800	10.16379	42
19	9.83634	9.86188	9.97447	10.02553	10.13812	10.16366	41
20	9.83648	9.86176	9.97472	10.02528	10.13824	10.16352	40
21	9.83661	9.86164	9.97497	10.02503	10.13836	10.16339	39
22	9.83674	9.86152	9.97523	10.02477	10.13848	10.16326	38
23	9.83688	9.86140	9.97548	10.02452	10.13860	10.16312	37
24	9.83701	9.86128	9.97573	10.02427	10.13872	10.16299	36
25	9.83715	9.86116	9.97599	10.02401	10.13884	10.16285	35
26	9.83728	9.86104	9.97624	10.02376	10.13896	10.16272	34
27	9.83741	9.86092	9.97649	10.02351	10.13908	10.16259	33
28	9.83755	9.86080	9.97674	10.02326	10.13920	10.16245	32
29	9.83768	9.86068	9.97700	10.02300	10.13932	10.16232	31
30	9.83781	9.86056	9.97725	10.02275	10.13944	10.16219	30
		Sine.		Tang.		Secant.	Min.

46 *Degrees.*

Tangents, and Secants.

43 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.83781	9.86056	9.97725	10.02275	10.13944	10.16219	30
31	9.83795	9.86044	9.97750	10.02250	10.13956	10.16205	29
32	9.83808	9.86032	9.97776	10.02224	10.13968	10.16192	28
33	9.83821	9.86020	9.97801	10.02199	10.13980	10.16179	27
34	9.83834	9.86008	9.97826	10.02174	10.13992	10.16166	26
35	9.83848	9.85996	9.97851	10.02149	10.14004	10.16152	25
36	9.83861	9.85984	9.97877	10.02123	10.14016	10.16139	24
37	9.83874	9.85972	9.97902	10.02098	10.14028	10.16126	23
38	9.83887	9.85960	9.97927	10.02073	10.14040	10.16113	22
39	9.83901	9.85948	9.97953	10.02047	10.14052	10.16099	21
40	9.83914	9.85936	9.97978	10.02022	10.14064	10.16086	20
41	9.83927	9.85924	9.98003	10.01997	10.14076	10.16073	19
42	9.83940	9.85912	9.98029	10.01971	10.14088	10.16060	18
43	9.83954	9.85900	9.98054	10.01946	10.14100	10.16046	17
44	9.83967	9.85888	9.98079	10.01921	10.14112	10.16033	16
45	9.83980	9.85876	9.98104	10.01896	10.14124	10.16020	15
46	9.83993	9.85864	9.98130	10.01870	10.14136	10.16007	14
47	9.84006	9.85851	9.98155	10.01845	10.14149	10.15994	13
48	9.84020	9.85839	9.98180	10.01820	10.14161	10.15980	12
49	9.84033	9.85827	9.98206	10.01794	10.14173	10.15967	11
50	9.84046	9.85815	9.98231	10.01769	10.14185	10.15954	10
51	9.84059	9.85803	9.98256	10.01744	10.14197	10.15941	9
52	9.84072	9.85791	9.98281	10.01719	10.14209	10.15928	8
53	9.84085	9.85779	9.98307	10.01693	10.14221	10.15915	7
54	9.84099	9.85766	9.98332	10.01668	10.14234	10.15901	6
55	9.84112	9.85754	9.98357	10.01643	10.14246	10.15888	5
56	9.84125	9.85742	9.98382	10.01617	10.14258	10.15875	4
57	9.84138	9.85730	9.98408	10.01592	10.14270	10.15862	3
58	9.84151	9.85718	9.98433	10.01567	10.14282	10.15849	2
59	9.84164	9.85706	9.98458	10.01542	10.14294	10.15836	1
60	9.84177	9.85693	9.98484	10.01516	10.14307	10.15823	0
		Sine.		Tang.		Secant.	Min.

46 Degrees.

A Table of Artificial Sines,

44 *Degrees.*

Min.	Sine.		Tang.		Secant.		
0	9.84177	9.85693	9.98484	10.01516	10.14307	10.15823	60
1	9.84190	9.85681	9.98509	10.01491	10.14319	10.15810	59
2	9.84203	9.85669	9.98534	10.01466	10.14331	10.15797	58
3	9.84216	9.85657	9.98560	10.01440	10.14343	10.15784	57
4	9.84229	9.85645	9.98585	10.01415	10.14355	10.15771	56
5	9.84242	9.85632	9.98610	10.01390	10.14368	10.15758	55
6	9.84255	9.85620	9.98635	10.01365	10.14380	10.15745	54
7	9.84269	9.85608	9.98661	10.01339	10.14392	10.15731	53
8	9.84282	9.85596	9.98686	10.01314	10.14404	10.15718	52
9	9.84295	9.85583	9.98711	10.01289	10.144 7	10.15705	51
10	9.84308	9.85571	9.98736	10.01264	10.14429	10.15692	50
11	9.84321	9.85559	9.98762	10.01238	10.14441	10.15679	49
12	9.84334	9.85547	9.98787	10.01213	10.14453	10.15660	48
13	9.84347	9.85534	9.98812	10.01183	10.14466	10.15653	47
14	9.84360	9.85522	9.98838	10.01162	10.14478	10.15640	46
15	9.84372	9.85510	9.98863	10.01137	10.14490	10.15628	45
16	9.84385	9.85497	9.98888	10.01112	10.14503	10.15615	44
17	9.84398	9.85485	9.98913	10.01087	10.14515	10.15602	43
18	9.84411	9.85473	9.98939	10.01061	10.14527	10.15589	42
19	9.84424	9.85460	9.98964	10.01036	10.14540	10.15576	41
20	9.84437	9.85448	9.98989	10.01011	10.14552	10.15563	40
21	9.84450	9.85436	9.99014	10.00986	10.14564	10.15550	39
22	9.84463	9.85423	9.99040	10.00960	10.14577	10.15537	38
23	9.84476	9.85411	9.99065	10.00935	10.14589	10.15524	37
24	9.84489	9.85399	9.99090	10.00910	10.14601	10.15511	36
25	9.84502	9.85386	9.99116	10.00884	10.14614	10.15498	35
26	9.84515	9.85374	9.99141	10.00859	10.14626	10.15485	34
27	9.84528	9.85361	9.99166	10.00834	10.14639	10.15472	33
28	9.84540	9.85349	9.99191	10.00809	10.14651	10.15460	32
29	9.84553	9.85337	9.99217	10.00783	10.14663	10.15447	31
30	9.84566	9.85324	9.99242	10.00758	10.14676	10.15434	30
		Sine.		Tang.		Secant.	Min.

45 *Degrees.*

Tangents, and Secants.

44 *Degrees.*

Min.	Sine.		Tang.		Secant.		
30	9.84566	9.85324	9.99242	10.00758	10.14676	10.15434	30
31	9.84579	9.85312	9.99267	10.00733	10.14684	10.15421	29
32	9.84592	9.85299	9.99293	10.00707	10.14701	10.15408	28
33	9.84605	9.85287	9.99318	10.00682	10.14713	10.15395	27
34	9.84618	9.85275	9.99343	10.00657	10.14725	10.15382	26
35	9.84630	9.85262	9.99368	10.00632	10.14738	10.15370	25
36	9.84643	9.85250	9.99394	10.00606	10.14750	10.15357	24
37	9.84656	9.85237	9.99419	10.00581	10.14763	10.15344	23
38	9.84669	9.85225	9.99444	10.00556	10.14775	10.15331	22
39	9.84682	9.85212	9.99469	10.00531	10.14788	10.15318	21
40	9.84694	9.85200	9.99495	10.00505	10.14800	10.15306	20
41	9.84707	9.85187	9.99520	10.00480	10.14813	10.15293	19
42	9.84720	9.85175	9.99545	10.00455	10.14825	10.15280	18
43	9.84733	9.85162	9.99570	10.00430	10.14838	10.15267	17
44	9.84745	9.85150	9 99596	10.00404	10.14850	10.15255	16
45	9.84758	9.85137	9.99621	10.00379	10.14863	10.15242	15
46	9.84771	9.85125	9.99646	10.00354	10.14875	10.15229	14
47	9.84784	9.85112	9.99672	10.00328	10.14888	10.15216	13
48	9.84796	9.85100	9.99697	10.00303	10.14900	10.15204	12
49	9.84809	9.85087	9.99722	10.00278	10.14913	10.15191	11
50	9.84822	9.85075	9.99747	10.00253	10.14925	10.15178	10
51	9.84835	9.85062	9.99773	10.00227	10.14938	10.15165	9
52	9.84847	9.85049	9.99798	10.00202	10.14951	10.15153	8
53	9.84860	9.85037	9.99823	10.00177	10.14963	10.15140	7
54	9.84873	9.85024	9.99848	10.00152	10.14976	10.15127	6
55	9.84885	9.85012	9.99874	10.00126	10.14988	10.15115	5
56	9.84898	9.84999	9.99899	10.00101	10.15001	10.15102	4
57	9.84911	9.84986	9.99924	10.00076	10.15014	10.15089	3
58	9.84923	9.84974	9.99949	10.00051	10.15026	10.15077	2
59	9.84936	9.84961	9.99975	10.00025	10.15039	10.15064	1
60	9.84949	9.84949	10.00000	10.00000	10.15051	10.15051	0
		Sine.		Tang.		Secant.	Min.

45 *Degrees.*

A TABLE *of the Declinations of ſome of the moſt Principal fixed Stars.*

Stars Names.	Declin.		Den.
SCHEDAR, in the Breaſt of *Caſſiopeia* — —	55	02	N
The bright Star of *Aries* — — — — —	22	08	N
Algol, the Head of *Meduſa* — — — — —	39	52	N
Aldebaran, the *Bull*'s Eye — — — — —	15	55	N
The *Goat* Star *Capella* — — — — — —	45	41	N
The Heart of *Hydra* — — — — — —	07	29	S
The Middlemoſt Star in *Orion*'s Belt — —	01	25	S
The Dog Star *Syrius* — — — — — —	16	21	S
Procyon, or the little Dog Star — — —	05	54	N
Caſtor, or the Head of the Northermoſt Twin	32	27	N
Pollux, or the Head of the Southermoſt Twin	28	39	N
Regulus, the *Lyon*'s Heart — — — — —	13	17	N
Deneb, the *Lyon*'s Tail — — — — — —	16	06	N
The *Virgin's Spike* — — — — — — —	09	45	S
Antares, the *Scorpion*'s Heart — — — — —	25	47	S
The Southermoſt of the two preceding Stars in the Square of the *Great Bear* — —	57	51	N
The Northermoſt of the ſame Two — —	63	13	N
The Southermoſt in the Two following Stars in the Square of the *Great Bear* — —	55	13	N
The Northermoſt of the ſame Two — —	58	34	N
The Firſt in the Tail of the *Great Bear* — —	57	28	N
The Second in the Tail — — — — —	56	22	N
The laſt of the Three in the Tail — — —	50	42	N
Arcturus — — — — — — — — —	20	39	N
Lyra, the bright Star in the *Harp* — — —	38	33	N
Altair, the bright Star in the *Eagle* — — —	08	10	N
The preceding of the two Middlemoſt in the *Croſs*	57	11	S
The Northern Foot of the *Croſs* — — —	55	30	S
The Southern Foot of the *Croſs* — — —	61	31	S
The Eaſtermoſt of the four Stars in the Croſs	58	06	S

F I N I S.

A Large and very useful

TABLE

OF

DIFFERENCE

OF

Latitude *and* Departure.

In Minutes and Tenth Parts, to every Degree and Quarter Point of the Compass, for the exact Working of a TRAVERSE, and readily finding the LONGITUDE by Inspection, according to middle Latitude.

U

Dist.	1 Deg. Lat.	1 Deg. Dep.	2 Deg. Lat.	2 Deg. Dep.	¼ Point Lat.	¼ Point Dep.	3 Deg. Lat.	3 Deg. Dep.	4 Deg. Lat.	4 Deg. Dep.	5 Deg. Lat.	5 Deg. Dep.	Dist.
1	01.0	00.0	01.0	00.0	01.0	00.0	01.0	00.0	01.0	00.1	01.0	00.1	1
2	02.0	00.0	02.0	00.1	02.0	00.1	02.0	00.1	02.0	00.1	02.0	00.2	2
3	03.0	00.1	03.0	00.1	03.0	00'1	03.0	00.2	03.0	00.2	03.0	00.3	3
4	04.0	00.1	04.0	00.1	04.0	00.2	04.0	00.2	04.0	00.3	04.0	00.3	4
5	05.0	00.1	05.0	00.2	05.0	00.2	05.0	00.3	05.0	00.3	05.0	00.4	5
6	06.0	00.1	06.0	00.2	06.0	00.3	06.0	00.3	06.0	00.4	06.0	00.5	6
7	07.0	00.1	07.0	00.2	07.0	00.3	07.0	00.4	07.0	00.5	07.0	00.6	7
8	08.0	00.1	08.0	00.3	08.0	00.4	08.0	00.4	08.0	00.6	08.0	00.7	8
9	09.0	00.2	09.0	00.3	09.0	00.4	09.0	00.5	09.0	00.6	09.0	00.8	9
10	10.0	00.2	10.0	00.4	10.0	00.5	10.0	00.5	10.0	00.7	10.0	00.9	10
11	11.0	00.2	11.0	00.4	11.0	00.5	11.0	00.6	11.0	00.8	11.0	01.0	11
12	12.0	00.2	12.0	00.4	12.0	00.6	12.0	00.6	12.0	00.8	12.0	01.0	12
13	13.0	00.2	13.0	00.5	13.0	00.6	13.0	00.7	13.0	00.9	12.9	01.1	13
14	14.0	00.2	14.0	00.5	14.0	00.7	14.0	00.7	14.0	01.0	13.9	01.2	14
15	15.0	00.3	15.0	00.5	15.0	00.7	15.0	00.8	15.0	01.0	14.9	01.3	15
16	16.0	00.3	16.0	00.6	16.0	00.8	16.0	00.8	16.0	01.1	15.9	01.4	16
17	17.0	00.3	17.0	00.6	17.0	00.8	17.0	00.9	17.0	01.2	16.9	01.5	17
18	18.0	00.3	18.0	00.6	18.0	00.9	18.0	00.9	17.9	01.3	17.9	01.6	18
19	19.0	00.3	19.0	00.7	19.0	00.9	19.0	01.0	18.9	01.3	18.9	01.7	19
20	20.0	00.4	20.0	00.7	20.0	01.0	20.0	01.0	19.9	01.4	19.9	01.7	20
21	21.0	00.4	21.0	00.7	21.0	01.0	21.0	01.1	20.9	01.5	20.9	01.8	21
22	22.0	00.4	22.0	00.8	22.0	01.1	22.0	01.1	21.9	01.5	21.9	01.9	22
23	23.0	00.4	23.0	00.8	23.0	01.1	23.0	01.2	22.9	01.6	22.9	02.0	23
24	24.0	00.4	24.0	00.8	24.0	01.2	24.0	01.3	23.9	01.7	23.9	02.1	24
25	25.0	00.4	25.0	00.9	25.0	01.2	25.0	01.3	24.9	01.7	24.9	02.2	25
26	26.0	00.5	26.0	00.9	26.0	01.3	26.0	01.4	25.9	01.8	25.9	02.3	26
27	27.0	00.5	27.0	00.9	27.0	01.3	27.0	01.4	26.9	01.9	26.9	02.4	27
28	28.0	00.5	28.0	01.0	28.0	01.4	28.0	01.5	27.9	02.0	27.9	02.4	28
29	29.0	00.5	29.0	01.0	29.0	01.4	29.0	01.5	28.9	02.0	28.9	02.5	29
30	30.0	00.5	30.0	01.1	30.0	01.5	30.0	01.6	29.9	02.1	29.9	02.6	30
31	31.0	00.5	31.0	01.1	30.9	01.5	31.0	01.6	30.9	02.2	30.9	02.7	31
32	32.0	00.6	32.0	01.1	31.9	01.6	31.9	01.7	31.9	02.2	31.9	02.8	32
33	33.0	00.6	33.0	01.2	32.9	01.6	32.9	01.7	32.9	02.3	32.9	02.9	33
34	34.0	00.6	34.0	01.2	33.9	01.7	33.9	01.8	33.9	02.4	33.9	03.0	34
35	35.0	00.6	35.0	01.2	34.9	01.7	34.9	01.8	34.9	02.4	34.9	03.1	35
36	36.0	00.6	36.0	01.3	35.9	01.8	35.9	01.9	35.9	02.5	35.9	03.1	36
37	37.0	00.7	37.0	01.3	36.9	01.8	36.9	01.9	36.9	02.6	36.9	03.2	37
38	38.0	00.7	38.0	01.3	37.9	01.9	37.9	02.0	37.9	02.7	37.9	03.3	38
39	39.0	00.7	39.0	01.4	38.9	01.9	38.9	02.0	38.9	02.7	38.9	03.4	39
40	40.0	00.7	40.0	01.4	39.9	02.0	39.9	02.1	39.9	02.8	39.8	03.5	40
41	41.0	00.7	41.0	01.4	40.9	02.0	40.9	02.1	40.9	02.9	40.8	03.6	41
42	42.0	00.7	42.0	01.5	41.9	02.1	41.9	02.2	41.9	02.9	41.8	03.7	42
43	43.0	00.8	43.0	01.5	42.9	02.1	42.9	02.2	42.9	03.0	42.8	03.8	43
44	44.0	00.8	44.0	01.5	43.9	02.2	43.9	02.3	43.9	03.1	43.8	03.8	44
45	45.0	00.8	45.0	01.6	44.9	02.2	44.9	02.4	44.9	03.1	44.8	03.9	45
46	46.0	00.8	46.0	01.6	45.9	02.2	45.9	02.4	45.9	03.2	45.8	04.0	46
47	47.0	00.8	47.0	01.6	46.9	02.3	46.9	02.5	46.9	03.3	46.8	04.1	47
48	48.0	00.8	48.0	01.7	47.9	02.3	47.9	02.5	47.9	03.4	47.8	04.2	48
49	49.0	00.9	49.0	01.7	48.9	02.4	48.9	02.6	48.9	03.4	48.8	04.3	49
50	50.0	00.9	50.0	01.8	49.9	02.4	49.9	02.6	49.9	03.5	49.8	04.4	50
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	89 Deg.		88 Deg.		7¾ Point		87 Deg.		86 Deg.		85 Deg.		

Dist.	1 Deg.		2 Deg.		¼ Point.		3 Deg.		4 Deg.		5 Deg.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	51.0	00.9	51.0	01.8	50.9	02.5	50.9	02.7	50.9	03.6	50.8	04.4	51
52	52.0	00.9	52.0	01.8	51.9	02.5	51.9	02.7	51.9	03.6	51.8	04.5	52
53	53.0	00.9	53.0	01.9	52.9	02.6	52.9	02.8	52.9	03.7	52.8	04.6	53
54	54.0	00.9	54.0	01.9	53.9	02.6	53.9	02.8	53.9	03.8	53.8	04.7	54
55	55.0	01.0	55.0	01.9	54.9	02.7	54.9	02.9	54.9	03.8	54.8	04.8	55
56	56.0	01.0	56.0	02.0	55.9	02.7	55.9	02.9	55.9	03.9	55.8	04.9	56
57	57.0	01.0	57.0	02.0	56.9	02.8	56.9	03.0	56.8	04.0	56.8	05.0	57
58	58.0	01.0	58.0	02.0	57.9	02.8	57.9	03.0	57.8	04.1	57.8	05.1	58
59	59.0	01.0	59.0	02.1	58.9	02.9	58.9	03.1	58.8	04.1	58.8	05.2	59
60	60.0	01.0	60.0	02.1	59.9	02.9	59.9	03.1	59.8	04.2	59.8	05.2	60
61	61.0	01.1	61.0	02.1	60.9	03.0	60.9	03.2	60.8	04.3	60.8	05.3	61
62	62.0	01.1	62.0	02.2	61.9	03.0	61.9	03.3	61.8	04.3	61.8	05.4	62
63	63.0	01.1	63.0	02.2	62.9	03.1	62.9	03.3	62.8	04.4	62.8	05.5	63
64	64.0	01.1	64.0	02.2	63.9	03.1	63.9	03.4	63.8	04.5	63.8	05.6	64
65	65.0	01.1	65.0	02.3	64.9	03.2	64.9	03.4	64.8	04.5	64.7	05.7	65
66	66.0	01.1	66.0	02.3	65.9	03.2	65.9	03.5	65.8	04.6	65.7	05.8	66
67	67.0	01.2	67.0	02.3	66.9	03.3	66.9	03.5	66.8	04.7	66.7	05.9	67
68	68.0	01.2	67.9	02.4	67.9	03.3	67.9	03.6	67.8	04.8	67.7	05.9	68
69	69.0	01.2	68.9	02.4	68.9	03.4	68.9	03.6	68.8	04.8	68.7	06.0	69
70	70.0	01.2	69.9	02.4	69.9	03.4	69.9	03.7	69.8	04.9	69.7	06.1	70
71	71.0	01.2	70.9	02.5	70.9	03.5	70.9	03.7	70.8	05.0	70.7	06.2	71
72	72.0	01.3	71.9	02.5	71.9	03.5	71.9	03.8	71.8	05.0	71.7	06.3	72
73	73.0	01.3	72.9	02.5	72.9	03.6	72.9	03.8	72.8	05.1	72.7	06.4	73
74	74.0	01.3	73.9	02.6	73.9	03.6	73.9	03.9	73.8	05.2	73.7	06.5	74
75	75.0	01.3	74.9	02.6	74.9	03.7	74.9	03.9	74.8	05.2	74.7	06.6	75
76	76.0	01.3	75.9	02.7	75.9	03.7	75.9	04.0	75.8	05.3	75.7	06.6	76
77	77.0	01.3	76.9	02.7	76.9	03.8	76.9	04.0	76.8	05.4	76.7	06.7	77
78	78.0	01.4	77.9	02.7	77.9	03.8	77.9	04.1	77.8	05.5	77.7	06.8	78
79	79.0	01.4	78.9	02.8	78.9	03.9	78.9	04.1	78.8	05.5	78.7	06.9	79
80	80.0	01.4	79.9	02.8	79.9	03.9	79.9	04.2	79.8	05.6	79.7	07.0	80
81	81.0	01.4	80.9	02.8	80.9	04.0	80.9	04.2	80.8	05.7	80.7	07.1	81
82	82.0	01.4	81.9	02.9	81.9	04.0	81.9	04.3	81.8	05.7	81.7	07.2	82
83	83.0	01.4	82.9	02.9	82.9	04.1	82.9	04.4	82.8	05.8	82.7	07.3	83
84	84.0	01.5	83.9	02.9	83.9	04.1	83.9	04.4	83.8	05.9	83.7	07.3	84
85	85.0	01.5	84.9	03.0	84.9	04.2	84.9	04.5	84.8	05.9	84.7	07.4	85
86	86.0	01.5	85.9	03.0	85.9	04.2	85.9	04.5	85.8	06.0	85.7	07.5	86
87	87.0	01.5	86.9	03.0	86.9	04.3	86.9	04.6	86.8	06.1	86.7	07.6	87
88	88.0	01.5	87.9	03.1	87.9	04.3	87.9	04.6	87.8	06.2	87.7	07.7	88
89	89.0	01.5	88.9	03.1	88.9	04.4	88.9	04.7	88.8	06.2	88.7	07.8	89
90	90.0	01.6	89.9	03.1	89.9	04.4	89.9	04.7	89.8	06.3	89.7	07.9	90
91	91.0	01.6	90.9	03.2	90.9	04.5	90.9	04.8	90.8	06.4	90.7	08.0	91
92	92.0	01.6	91.9	03.2	91.9	04.5	91.9	04.8	91.8	06.4	91.6	08.0	92
93	93.0	01.6	92.9	03.2	92.9	04.6	92.9	04.9	92.8	06.5	92.6	08.1	93
94	94.0	01.6	93.9	03.3	93.9	04.6	93.9	04.9	93.8	06.6	93.6	08.2	94
95	95.0	01.6	94.9	03.3	94.9	04.7	94.9	05.0	94.8	06.6	94.6	08.3	95
96	96.0	01.7	95.9	03.4	95.9	04.7	95.9	05.0	95.8	06.7	95.6	08.4	96
97	97.0	01.7	96.9	03.4	96.9	04.8	96.9	05.1	96.8	06.8	96.6	08.5	97
98	98.0	01.7	97.9	03.4	97.9	04.8	97.9	05.1	97.8	06.9	97.6	08.6	98
99	99.0	01.7	98.9	03.5	98.9	04.9	98.9	05.2	98.8	06.9	98.6	08.7	99
100	100.0	01.7	99.9	03.5	99.9	04.9	99.9	05.2	99.8	07.0	99.6	08.7	100
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	89 Deg.		88 Deg.		7¾ Point.		87 Deg.		86 Deg.		85 Deg.		

Dist.	½ Point		6 Deg.		7 Deg.		8 Deg.		¾ Point		9 Deg.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	01.0	00.1	01.0	00.1	01.0	00.1	01.0	00.1	01.0	00.1	01.0	00.2	1
2	02.0	00.2	02.0	00.2	02.0	00.2	02.0	00.3	02.0	00.3	02.0	00.3	2
3	03.0	00.3	03.0	00.3	03.0	00.4	03.0	00.4	03.0	00.4	03.0	00.5	3
4	04.0	00.4	04.0	00.4	04.0	00.5	04.0	00.6	04.0	00.6	03.9	00.6	4
5	05.0	00.5	05.0	00.5	05.0	00.6	04.9	00.7	04.9	00.7	04.9	00.8	5
6	06.0	00.6	06.0	00.6	06.0	00.7	05.9	00.8	05.9	00.9	05.9	00.9	6
7	07.0	00.7	07.0	00.7	06.9	00.8	06.9	01.0	06.9	01.0	06.9	01.1	7
8	08.0	00.8	08.0	00.8	07.9	01.0	07.9	01.1	07.9	01.2	07.9	01.2	8
9	09.0	00.9	08.9	00.9	08.9	01.1	08.9	01.2	08.9	01.3	08.9	01.4	9
10	09.9	01.0	09.9	01.0	09.9	01.2	09.9	01.4	09.9	01.5	09.9	01.6	10
11	10.9	01.1	10.9	01.1	10.9	01.3	10.9	01.5	10.9	01.6	10.9	01.7	11
12	11.9	01.2	11.9	01.2	11.9	01.5	11.9	01.7	11.9	01.8	11.8	01.9	12
13	12.9	01.3	12.9	01.4	12.9	01.6	12.9	01.8	12.9	01.9	12.8	02.0	13
14	13.9	01.4	13.9	01.5	13.9	01.7	13.9	01.9	13.8	02.1	13.8	02.2	14
15	14.9	01.5	14.9	01.6	14.9	01.8	14.8	02.1	14.8	02.2	14.8	02.3	15
16	15.9	01.6	15.9	01.7	15.9	01.9	15.8	02.2	15.8	02.3	15.8	02.5	16
17	16.9	01.7	16.9	01.8	16.9	02.1	16.8	02.4	16.8	02.5	16.8	02.7	17
18	17.9	01.8	17.9	01.9	17.9	02.2	17.8	02.5	17.8	02.6	17.8	02.8	18
19	18.9	01.9	18.9	02.0	18.9	02.3	18.8	02.6	18.8	02.8	18.8	03.0	19
20	19.9	02.0	19.9	02.1	19.8	02.4	19.8	02.8	19.8	02.9	19.7	03.1	20
21	20.9	02.1	20.9	02.2	20.8	02.6	20.8	02.9	20.8	03.1	20.7	03.3	21
22	21.9	02.2	21.9	02.3	21.8	02.7	21.8	03.1	21.8	03.2	21.7	03.4	22
23	22.9	02.2	22.9	02.4	22.8	02.8	22.8	03.2	22.7	03.4	22.7	03.6	23
24	23.9	02.3	23.9	02.5	23.8	02.9	23.8	03.3	23.7	03.5	23.7	03.8	24
25	24.9	02.4	24.9	02.6	24.8	03.0	24.8	03.5	24.7	03.7	24.7	03.9	25
26	25.9	02.5	25.9	02.7	25.8	03.2	25.7	03.6	25.7	03.8	25.7	04.1	26
27	26.9	02.6	26.9	02.8	26.8	03.3	26.7	03.7	26.7	04.0	26.7	04.2	27
28	27.9	02.7	27.8	02.9	27.8	03.4	27.7	03.9	27.7	04.1	27.6	04.4	28
29	28.9	02.8	28.8	03.0	28.8	03.5	28.7	04.0	28.7	04.2	28.6	04.5	29
30	29.8	02.9	29.8	03.1	29.8	03.7	29.7	04.2	29.7	04.4	29.6	04.7	30
31	30.8	03.0	30.8	03.2	30.8	03.8	30.7	04.3	30.7	04.5	30.6	04.9	31
32	31.8	03.1	31.8	03.3	31.8	03.9	31.7	04.4	31.6	04.7	31.6	05.0	32
33	32.8	03.2	32.8	03.4	32.7	04.0	32.7	04.6	32.6	04.8	32.6	05.2	33
34	33.8	03.3	33.8	03.5	33.7	04.1	33.7	04.7	33.6	05.0	33.6	05.3	34
35	34.8	03.4	34.8	03.7	34.7	04.3	34.7	04.9	34.6	05.1	34.6	05.5	35
36	35.8	03.5	35.8	03.8	35.7	04.4	35.6	05.0	35.6	05.3	35.5	05.6	36
37	36.8	03.6	36.8	03.9	36.7	04.5	36.6	05.1	36.6	05.4	36.5	05.8	37
38	37.8	03.7	37.8	04.0	37.7	04.6	37.6	05.3	37.6	05.6	37.5	06.0	38
39	38.8	03.8	38.8	04.1	38.7	04.8	38.6	05.4	38.6	05.7	38.5	06.1	39
40	39.8	03.9	39.8	04.2	39.7	04.9	39.6	05.6	39.6	05.9	39.5	06.3	40
41	40.8	04.0	40.8	04.3	40.7	05.0	40.6	05.7	40.6	06.0	40.5	06.4	41
42	41.8	04.1	41.8	04.4	41.7	05.1	41.6	05.8	41.5	06.2	41.5	06.6	42
43	42.8	04.2	42.8	04.5	42.7	05.2	42.6	06.0	42.5	06.3	42.5	06.7	43
44	43.8	04.3	43.7	04.6	43.7	05.4	43.6	06.1	43.5	06.5	43.5	06.9	44
45	44.8	04.4	44.7	04.7	44.7	05.5	44.6	06.3	44.5	06.6	44.4	07.0	45
46	45.8	04.5	45.7	04.8	45.7	05.6	45.5	06.4	45.5	06.7	45.4	07.2	46
47	46.8	04.6	46.7	04.9	46.6	05.7	46.5	06.5	46.5	06.9	46.4	07.3	47
48	47.8	04.7	47.7	05.0	47.6	05.9	47.5	06.7	47.5	07.0	47.4	07.5	48
49	48.8	04.8	48.7	05.1	48.6	06.0	48.5	06.8	48.5	07.2	48.4	07.7	49
50	49.8	04.9	49.7	05.2	49.6	06.1	49.5	07.0	49.5	07.3	49.4	07.8	50
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	7½ Point		84 Deg.		83 Deg.		82 Deg.		7¼ Point		81 Deg.		

Dist.	½ Point Lat.	½ Point Dep.	6 Deg. Lat.	6 Deg. Dep.	7 Deg. Lat.	7 Deg. Dep.	8 Deg. Lat.	8 Deg. Dep	¾ Point Lat.	¾ Point Dep	9 Deg. Lat.	9 Deg. Dep.	Dist.
51	50.7	05.0	50.7	05.3	50.6	06.2	50.5	07.1	50.4	07.5	50.4	08.0	51
52	51.7	05.1	51.7	05.4	51.6	06.3	51.5	07.2	51.4	07.6	51.4	08.1	52
53	52.7	05.2	52.7	05.5	52.6	06.4	52.5	07.4	52.4	07.8	52.3	08.3	53
54	53.7	05.3	53.7	05.6	53.6	06.6	53.5	07.5	53.4	07.9	53.3	08.4	54
55	54.7	05.4	54.7	05.7	54.6	06.7	54.5	07.6	54.4	08.1	54.3	08.6	55
56	55.7	05.5	55.7	05.8	55.6	06.8	55.5	07.8	55.4	08.2	55.3	08.7	56
57	56.7	05.6	56.7	06.0	56.6	06.9	56.4	07.9	56.4	08.4	56.3	08.9	57
58	57.7	05.7	57.7	06.1	57.6	07.1	57.4	08.1	57.4	08.5	57.3	09.1	58
59	58.7	05.8	58.7	06.2	58.6	07.2	58.4	08.2	58.4	08.7	58.3	09.2	59
60	59.7	05.9	59.7	06.3	59.5	07.3	59.4	08.3	59.4	08.8	59.3	09.4	60
61	60.7	06.0	60.7	06.4	60.5	07.4	60.4	08.5	60.3	08.9	60.2	09.5	61
62	61.7	06.1	61.6	06.5	61.5	07.6	61.4	08.6	61.3	09.1	61.2	09.7	62
63	62.7	06.2	62.6	06.6	62.5	07.7	62.4	08.8	62.3	09.2	62.2	09.9	63
64	63.7	06.3	63.6	06.7	63.5	07.8	63.4	08.9	63.3	09.4	63.2	10.0	64
65	64.7	06.4	64.6	06.8	64.5	07.9	64.4	09.1	64.3	09.5	64.2	10.2	65
66	65.6	06.5	65.6	06.9	65.5	08.0	65.4	09.2	65.3	09.7	65.2	10.3	66
67	66.6	06.6	66.6	d7.0	66.5	08.2	66.3	09.3	66.3	09.8	66.2	10.5	67
68	67.6	06.7	67.6	07.1	67.5	08.3	67.3	09.5	67.3	10.0	67.2	10.6	68
69	68.6	06.8	68.6	07.2	68.5	08.4	68.3	09.6	68.2	10.1	68.1	10.8	69
70	69.6	06.9	69.6	07.3	69.5	08.5	69.3	09.7	69.2	10.3	69.1	10.9	70
71	70.6	07.0	70.6	07.4	70.5	08.7	70.3	09.9	70.2	10.4	70.1	11.1	71
72	71.6	07.1	71.6	07.5	71.5	08.8	71.3	10.0	71.2	10.6	71.1	11.3	72
73	72.6	07.1	72.6	07.6	72.4	08.9	72.3	10.2	72.2	10.7	72.1	11.4	73
74	73.6	07.2	73.6	07.7	73.4	09.0	73.3	10.3	73.2	10.9	73.1	11.6	74
75	74.6	07.3	74.6	07.8	74.4	09.1	74.3	10.4	74.2	11.0	74.1	11.7	75
76	75.6	07.4	75.6	07.9	75.4	09.3	75.3	10.6	75.2	11.1	75.1	11.9	76
77	76.6	07.5	76.6	08.0	76.4	09.4	76.2	10.7	76.2	11.3	76.0	12.0	77
78	77.6	07.6	77.6	08.1	77.4	09.5	77.2	10.9	77.1	11.4	77.0	12.2	78
79	78.6	07.7	78.6	08.3	78.4	09.6	78.2	11.0	78.1	11.6	78.0	12.4	79
80	79.6	07.8	79.6	08.4	79.4	09.8	79.2	11.1	79.1	11.7	79.0	12.5	80
81	80.6	07.9	80.5	08.5	80.4	09.9	80.2	11.3	80.1	11.9	80.0	12.7	81
82	81.6	08.0	81.5	08.6	81.4	10.0	81.2	11.4	81.1	12.0	81.0	12.8	82
83	82.6	08.1	82.5	08.7	82.4	10.1	82.2	11.5	82.1	12.2	82.0	13.0	83
84	83.6	08.2	83.5	08.8	83.4	10.2	83.2	11.7	83.1	12.3	83.0	13.1	84
85	84.6	08.3	84.5	08.9	84.4	10.3	84.2	11.8	84.1	12.5	83.9	13.3	85
86	85.6	08.4	85.5	09.0	85.4	10.4	85.2	12.0	85.1	12.6	84.9	13.4	86
87	86.6	08.5	86.5	09.1	86.3	10.5	86.1	12.1	86.0	12.8	85.9	13.6	87
88	87.6	08.6	87.5	09.2	87.3	10.7	87.1	12.2	87.0	12.9	86.9	13.8	88
89	88.6	08.7	88.5	09.3	88.3	10.9	88.1	12.4	88.0	13.1	87.9	13.9	89
90	89.6	08.8	89.5	09.4	89.3	11.0	89.1	12.5	89.0	13.2	88.9	14.1	90
91	90.6	08.9	90.5	09.5	90.3	11.1	90.1	12.7	90.0	13.4	89.9	14.2	91
92	91.6	09.0	91.5	09.6	91.3	11.2	91.1	12.8	91.0	13.5	90.8	14.4	92
93	92.6	09.1	92.5	09.7	92.3	11.3	92.1	12.9	92.0	13.6	91.8	14.5	93
94	93.5	09.2	93.5	09.8	93.3	11.5	93.1	13.1	93.0	13.8	92.8	14.7	94
95	94.5	09.3	94.5	09.9	94.3	11.6	94.1	13.2	94.0	13.9	93.8	14.9	95
96	95.5	09.4	95.5	10.0	95.3	11.7	95.1	13.4	95.0	14.1	94.8	15.0	96
97	96.5	09.5	96.5	10.1	96.3	11.8	96.0	13.5	95.9	14.2	95.8	15.2	97
98	97.5	09.6	97.5	10.2	97.3	12.0	97.0	13.6	96.9	14.4	96.8	15.3	98
99	98.5	09.7	98.5	10.3	98.3	12.1	98.0	13.8	97.9	14.5	97.8	15.5	99
100	99.5	09.8	99.4	10.4	99.2	12.2	99.0	13.9	98.9	14.7	98.8	15.6	100
Dist.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat	Dep.	Lat.	Dep.	Lat.	Dist.
	7½ Point		84 Deg.		83 Deg		82 Deg.		7¼ Point		81 Deg.		

Dist.	10 Deg.		11 Deg.		1 Point.		12 Deg.		13 Deg.		14 Deg.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	01.0	00.2	01.0	00.2	01.0	00.2	01.0	00.2	01.0	00.2	01.0	00.2	1
2	02.0	00.3	02.0	00.4	02.0	00.4	02.0	00.4	01.9	00.4	01.9	00.5	2
3	02.9	00.5	02.9	00.6	02.9	00.6	02.9	00.6	02.9	00.7	02.9	00.7	3
4	03.9	00.7	03.9	00.8	03.9	00.8	03.9	00.8	03.9	00.9	03.9	01.0	4
5	04.9	00.9	04.9	00.9	04.9	01.0	04.9	01.0	04.9	01.1	04.8	01.2	5
6	05.9	01.0	05.9	01.1	05.9	01.2	05.9	01.2	05.8	01.3	05.8	01.4	6
7	06.9	01.2	06.9	01.3	06.9	01.4	06.8	01.5	06.8	01.6	06.8	01.7	7
8	07.9	01.4	07.8	01.5	07.8	01.6	07.8	01.7	07.8	01.8	07.8	01.9	8
9	08.9	01.6	08.8	01.7	08.8	01.8	08.8	01.9	08.8	02.0	08.7	02.2	9
10	09.8	01.7	09.8	01.9	09.8	01.9	09.8	02.1	09.7	02.2	09.7	02.4	10
11	10.8	01.9	10.8	02.1	10.8	02.1	10.8	02.3	10.7	02.5	10.7	02.7	11
12	11.8	02.1	11.8	02.3	11.8	02.3	11.7	02.5	11.7	02.7	11.6	02.9	12
13	12.8	02.3	12.8	02.5	12.7	02.5	12.7	02.7	12.7	02.9	12.6	03.1	13
14	13.8	02.4	13.7	02.7	13.7	02.7	13.7	02.9	13.6	03.1	13.6	03.3	14
15	14.8	02.6	14.7	02.9	14.7	02.9	14.7	03.1	14.6	03.4	14.5	03.6	15
16	15.7	02.8	15.7	03.0	15.7	03.1	15.6	03.3	15.6	03.6	15.5	03.9	16
17	16.7	02.9	16.7	03.2	16.7	03.3	16.6	03.5	16.6	03.8	16.5	04.1	17
18	17.7	03.1	17.7	03.4	17.7	03.6	17.6	03.7	17.5	04.0	17.5	04.4	18
19	18.7	03.3	18.6	03.6	18.6	03.7	18.6	03.9	18.5	04.2	18.4	04.6	19
20	19.7	03.5	19.6	03.8	19.6	03.9	19.6	04.2	19.5	04.5	19.4	04.8	20
21	20.7	03.6	20.6	04.0	20.6	04.1	20.5	04.4	20.5	04.7	20.4	05.1	21
22	21.7	03.8	21.6	04.2	21.6	04.3	21.5	04.6	21.4	04.9	21.3	05.3	22
23	22.6	04.0	22.6	04.4	22.6	04.5	22.5	04.8	22.4	05.2	22.3	05.6	23
24	23.6	04.2	23.6	04.6	23.5	04.7	23.5	05.0	23.4	05.4	23.3	05.8	24
25	24.6	04.3	24.5	04.8	24.5	04.9	24.4	05.2	24.3	05.6	24.3	06.0	25
26	25.6	04.5	25.5	05.0	25.5	05.1	25.4	05.4	25.3	05.8	25.2	06.3	26
27	26.6	04.7	26.5	05.1	26.5	05.3	26.4	05.6	26.3	06.1	26.2	06.5	27
28	27.6	04.9	27.5	05.3	27.5	05.5	27.4	05.8	27.3	06.3	27.2	06.8	28
29	28.6	05.0	28.5	05.5	28.4	05.7	28.4	06.0	28.2	06.5	28.1	07.0	29
30	29.5	05.2	29.4	05.7	29.4	05.8	29.3	06.2	29.2	06.7	29.1	07.3	30
31	30.5	05.4	30.4	05.9	30.4	06.0	30.3	06.4	30.2	07.0	30.1	07.5	31
32	31.5	05.5	31.4	06.1	31.4	06.2	31.3	06.6	31.2	07.2	31.0	07.7	32
33	32.5	05.7	32.4	06.3	32.4	06.4	32.3	06.9	32.1	07.4	32.0	08.0	33
34	33.5	05.9	33.4	06.5	33.3	06.6	33.2	07.1	33.1	07.6	33.0	08.2	34
35	34.5	06.1	34.4	06.7	34.3	06.8	34.2	07.3	34.1	07.9	34.0	08.5	35
36	35.4	06.2	35.3	06.9	35.3	07.0	35.2	07.5	35.1	08.1	34.9	08.7	36
37	36.4	06.4	36.3	07.1	36.3	07.2	36.2	07.7	36.0	08.3	35.9	09.0	37
38	37.4	06.6	37.3	07.2	37.3	07.4	37.2	07.9	37.0	08.5	36.9	09.2	38
39	38.4	06.8	38.3	07.4	38.2	07.6	38.1	08.1	38.0	08.8	37.8	09.4	39
40	39.4	06.9	39.3	07.6	39.2	07.8	39.1	08.3	39.0	09.0	38.8	09.7	40
41	40.4	07.1	40.2	07.8	40.2	08.0	40.1	08.5	39.9	09.2	39.8	09.9	41
42	41.4	07.3	41.2	08.0	41.2	08.2	41.1	08.7	40.9	09.4	40.7	10.2	42
43	42.3	07.5	42.2	08.2	42.2	08.4	42.1	08.9	41.9	09.7	41.7	10.4	43
44	43.3	07.7	43.2	08.4	43.1	08.6	43.0	09.1	42.9	09.9	42.7	10.6	44
45	44.3	07.8	44.2	08.6	44.1	08.8	44.0	09.4	43.8	10.1	43.7	11.0	45
46	45.3	08.0	45.2	08.8	45.1	09.0	45.0	09.6	44.8	10.3	44.6	11.1	46
37	46.3	08.1	46.1	09.0	46.1	09.2	46.0	09.8	45.8	10.6	45.6	11.4	47
48	47.3	08.3	47.1	09.2	47.1	09.4	47.0	10.0	46.8	10.8	46.6	11.6	48
49	48.3	08.5	48.1	09.3	48.1	09.6	47.9	10.2	47.7	11.9	47.5	11.9	49
50	49.2	08.7	49.1	09.5	49.0	09.8	48.9	10.4	48.7	11.2	48.5	12.1	50
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	80 Deg.		79 Deg.		7 Point.		78 Deg.		77 Deg		76 Deg.		

Dist.	10 Deg.		11 Deg.		1 Point.		12 Deg.		13 Deg.		14 Deg.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.2	08.8	50.1	09.7	50.0	10.0	49.9	10.6	49.7	11.5	49.5	12.3	51
52	51.2	09.0	51.0	09.9	51.0	10.1	50.9	10.8	50.7	11.7	50.5	12.6	52
53	52.2	09.2	52.0	10.1	52.0	10.3	51.8	11.0	51.6	11.9	51.4	12.8	53
54	53.2	09.4	53.0	10.3	53.0	10.5	52.8	11.2	52.6	12.1	52.4	13.1	54
55	54.2	09.5	54.0	10.5	53.9	10.7	53.8	11.4	53.6	12.4	53.4	13.3	55
56	55.1	09.7	55.0	10.7	54.9	10.9	54.8	11.6	54.5	12.6	54.3	13.5	56
57	56.1	09.9	56.0	10.8	55.9	11.1	55.8	11.8	55.5	12.8	55.3	13.8	57
58	57.1	10.1	56.9	11.1	56.9	11.3	56.7	12.1	56.5	13.0	56.3	14.0	58
59	58.1	10.2	57.9	11.3	57.9	11.5	57.7	12.3	57.5	13.3	57.2	14.3	59
60	59.1	10.4	58.9	11.4	58.8	11.7	58.7	12.5	58.5	13.5	58.2	14.5	60
61	60.1	10.6	59.9	11.6	59.8	11.9	59.7	12.7	59.4	13.7	59.2	14.8	61
62	61.1	10.8	60.9	11.8	60.8	12.1	60.6	12.9	60.4	13.9	60.2	15.0	62
63	62.0	10.9	61.8	12.0	61.8	12.3	61.6	13.1	61.4	14.2	61.1	15.2	63
64	63.0	11.1	62.8	12.2	62.8	12.5	62.6	13.3	62.4	14.4	62.1	15.5	64
65	64.0	11.3	63.8	12.4	63.7	12.7	63.6	13.5	63.3	14.6	63.1	15.7	65
66	65.0	11.5	64.8	12.6	64.7	12.9	64.6	13.7	64.3	14.8	64.0	16.0	66
67	66.0	11.6	65.8	12.8	65.7	13.1	65.5	13.9	65.3	15.1	65.0	16.2	67
68	67.0	11.8	66.7	13.0	66.7	13.3	66.5	14.1	66.2	15.3	66.0	16.4	68
69	68.0	12.0	67.7	13.2	67.7	13.5	67.5	14.3	67.2	15.5	66.9	16.7	69
70	68.9	12.2	68.7	13.4	68.7	13.7	68.5	14.5	68.2	15.7	67.9	16.9	70
71	69.9	12.3	69.7	13.5	69.6	13.9	69.4	14.8	69.2	16.0	68.9	17.2	71
72	70.9	12.5	70.7	13.7	70.6	14.0	70.4	15.0	70.1	16.2	69.9	17.4	72
73	71.9	12.7	71.7	13.9	71.6	14.2	71.4	15.2	71.1	16.4	70.8	17.6	73
74	72.9	12.8	72.6	14.1	72.6	14.4	72.4	15.4	72.1	16.6	71.8	17.9	74
75	73.9	13.0	73.6	14.3	73.6	14.6	73.4	15.6	73.1	16.9	72.8	18.1	75
76	74.8	13.2	74.6	14.5	74.5	14.8	74.3	15.8	74.0	17.1	73.7	18.4	76
77	75.8	13.4	75.6	14.7	75.5	15.0	75.3	16.0	75.0	17.3	74.7	18.6	77
78	76.8	13.5	76.6	14.9	76.5	15.2	76.3	16.2	76.0	17.5	75.7	18.9	78
79	77.8	13.7	77.5	15.1	77.5	15.4	77.3	16.4	77.0	17.8	76.6	19.1	79
80	78.8	13.9	78.5	15.3	78.5	15.6	78.2	16.6	77.9	18.0	77.6	19.3	80
81	79.8	14.1	79.5	15.5	79.4	15.8	79.2	16.8	78.9	18.2	78.6	19.4	81
82	80.8	14.2	80.5	15.6	80.4	16.0	80.2	17.0	79.9	18.4	79.6	19.8	82
83	81.7	14.4	81.5	15.8	81.4	16.2	81.2	17.2	80.9	18.7	80.5	20.1	83
84	82.7	14.6	82.5	16.0	82.4	16.4	82.2	17.5	81.8	18.9	81.5	20.3	84
85	83.7	14.8	83.4	16.2	83.4	16.6	83.1	17.7	82.8	19.1	82.5	20.6	85
86	84.7	14.9	84.4	16.4	84.3	16.8	84.1	17.9	83.8	19.3	83.4	20.8	86
87	85.7	15.1	85.4	16.6	85.3	17.0	85.1	18.1	84.8	19.6	84.4	21.0	87
88	86.7	15.3	86.4	16.8	86.3	17.2	86.1	18.3	85.7	19.8	85.4	21.3	88
89	87.6	15.4	87.4	17.0	87.3	17.4	87.1	18.5	86.7	20.0	86.4	21.5	89
90	88.6	15.6	88.3	17.2	88.3	17.6	88.0	18.7	87.7	20.2	87.3	21.8	90
91	89.6	15.8	89.3	17.4	89.2	17.8	89.0	18.9	88.7	20.5	88.3	22.0	91
92	90.6	16.0	90.3	17.6	90.2	17.9	90.0	19.1	89.6	20.7	89.3	22.2	92
93	91.6	16.1	91.3	17.7	91.2	18.1	91.0	19.3	90.6	20.9	90.2	22.5	93
94	92.6	16.3	92.3	17.9	92.2	18.3	91.9	19.5	91.6	21.1	91.2	22.7	94
95	93.5	16.5	93.3	18.1	93.2	18.5	92.9	19.7	92.6	21.4	92.2	23.0	95
96	94.5	16.7	94.2	18.3	94.2	18.7	93.9	20.0	93.5	21.6	93.1	23.2	96
97	95.5	16.8	95.2	18.5	95.1	18.9	94.9	20.2	94.5	21.8	94.1	23.5	97
98	96.5	17.0	96.2	18.7	96.1	19.1	95.9	20.4	95.5	22.0	95.1	23.7	98
99	97.5	17.2	97.2	18.9	97.2	19.3	96.8	20.6	96.5	22.3	96.1	23.9	99
100	98.5	17.4	98.2	19.1	98.1	19.5	97.8	20.8	97.4	22.5	97.0	24.2	100
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	80 Deg.		79 Deg.		7 Point.		78 Deg.		77 Deg.		76 Deg.		

Dist.	1 $\frac{1}{4}$ Point.		15 Deg.		16 Deg.		1 $\frac{1}{2}$ Point.		17 Deg.		18 Deg.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	01.0	00.2	01.0	00.3	01.0	00.3	01.0	00.3	01.0	00.3	01.c	00.3	1
2	01.9	00.5	01.9	00.5	01.9	00.5	01.9	00.6	01.9	00.6	01.9	00.6	2
3	02.9	00.7	02.9	00.8	02.9	00.8	02.9	00.9	02.9	00.9	02.8	00.9	3
4	03.9	01.0	03.9	01.0	03.8	01.1	03.8	01.2	03.8	01.2	03.8	01.2	4
5	04.8	01.2	04.8	01.3	04.8	01.4	04.8	01.5	04.8	01.5	04.8	01.5	5
6	05.8	01.5	05.8	01.5	05.8	01.6	05.8	01.7	05.7	01.7	05.5	01.8	6
7	06.8	01.7	06.8	01.8	06.8	01.9	06.7	02.0	06.7	02.0	06.6	02.2	7
8	07.8	01.9	07.7	02.1	07.7	02.2	07.7	02.3	07.6	02.3	07.6	02.5	8
9	08.7	02.2	08.7	02.3	08.6	02.5	08.6	02.6	08.6	02.6	08.7	02.8	9
10	09.7	02.4	09.7	02.6	09.6	02.8	09.6	02.9	09.6	02.9	c9.7	03.1	10
11	10.7	02.8	10.6	02.8	10.6	03.0	10.5	03.2	10.5	03.2	10.5	03.4	11
12	11.6	02.9	11.6	03.1	11.5	03.3	11.5	03.7	11.5	03.5	11.4	03.7	12
13	12.6	03.2	12.6	03.4	12.5	03.6	12.5	03.8	12.4	03.8	12.4	04.0	13
14	13.6	03.4	13.5	03.6	13.5	03.9	13.4	04.1	13.4	04.1	13.3	04.3	14
15	14.5	03.6	14.5	03.9	14.4	04.1	14.4	04.4	14.3	04.4	14.3	04.6	15
16	15.5	04.0	15.5	04.1	15.4	04.4	15.3	04.6	15.3	04.7	15.2	04.9	16
17	16.5	04.1	16.4	04.4	16.3	04.7	16.3	04.9	16.3	05.0	16.2	05.2	17
18	17.5	04.4	17.4	04.7	17.3	05.0	17.2	05.2	17.2	05.3	17.1	05.6	18
19	18.4	04.6	18.4	04.9	18.3	05.2	18.2	05.5	18.2	05.5	18.1	05.9	19
20	19.4	04.9	19.3	05.2	19.2	05.5	19.1	05.8	19.1	05.8	19.0	06.2	20
21	20.4	05.1	20.3	05.4	20.2	05.8	20.1	06.1	20.1	06.1	20.0	06.5	21
22	21.3	05.3	21.2	05.7	21.1	06.1	21.0	06.4	21.0	06.4	20.9	06.8	22
23	22.3	05.6	22.2	06.0	22.1	06.3	22.0	06.7	22.0	06.7	21.9	07.1	23
24	23.3	05.8	23.2	06.2	23.1	06.6	23.0	06.8	22.9	07.0	22.8	07.4	24
25	24.2	06.0	24.1	06.5	24.0	06.9	23.9	07.3	23.9	07.3	23.8	07.7	25
26	25.2	06.3	25.1	06.7	24.9	07.2	24.9	07.5	24.9	07.6	24.7	08.0	26
27	26.2	06.6	26.1	07.0	25.9	07.4	25.8	07.8	25.8	07.9	25.7	08.3	27
28	27.2	06.8	27.0	07.2	26.9	07.7	26.8	08.1	26.8	08.2	26.6	08.6	28
29	28.1	07.0	28.0	07.5	27.8	08.0	27.8	08.4	27.7	08.5	27.6	09.0	29
30	29.1	07.3	29.0	07.8	28.8	08.3	28.7	08.7	28.7	08.8	28.5	09.3	30
31	30.1	07.5	29.9	08.0	29.8	08.5	29.7	09.0	29.6	09.1	29.5	09.6	31
32	31.0	07.9	30.9	08.3	30.7	08.8	30.6	09.3	30.6	09.3	30.4	10.0	32
33	32.0	08.0	31.9	08.5	31.7	09.1	31.6	09.6	31.6	09.6	31.4	10.2	33
34	33.0	08.3	32.8	08.8	32.7	09.4	32.5	09.9	32.5	09.9	32.3	10.5	34
35	33.9	08.5	33.8	09.0	33.6	09.6	33.5	10.2	33.5	10.2	33.3	10.8	35
36	34.9	08.7	34.8	09.3	34.6	09.9	34.4	10.4	34.4	10.5	34.2	11.1	36
37	35.9	09.0	35.7	09.6	35.6	10.2	35.4	10.7	35.4	10.8	35.2	11.4	37
38	36.9	09.2	36.7	09.8	36.5	10.5	36.4	11.0	36.3	11.1	36.1	11.7	38
39	37.8	09.5	37.7	10.1	37.5	10.7	37.3	11.3	37.3	11.4	37.1	12.0	39
40	38.8	09.7	38.6	10.3	38.4	11.0	38.3	11.6	38.2	11.7	38.0	12.4	40
41	39.8	10.0	39.6	10.6	39.4	11.3	39.2	11.9	39.2	12.0	39.0	12.7	41
42	40.7	10.2	40.6	10.9	40.4	11.6	40.2	12.2	40.2	12.3	39.9	13.0	42
43	41.7	10.4	41.5	11.1	41.3	11.8	41.1	12.5	41.1	12.6	40.9	13.3	43
44	42.7	10.7	42.5	11.5	42.3	12.1	42.1	12.8	42.1	12.9	41.8	13.6	44
45	43.6	10.9	43.5	11.6	43.3	12.4	43.1	13.1	43.0	13.1	42.8	13.9	45
46	44.6	11.2	44.4	11.9	44.2	12.7	44.0	13.3	44.0	13.4	43.7	14.2	46
47	45.6	11.4	45.4	12.2	45.2	12.9	45.0	13.6	44.9	13.7	44.7	14.5	47
48	46.6	11.7	46.4	12.4	46.1	13.2	45.9	13.9	45.9	14.0	45.6	14.8	48
49	47.5	11.9	47.3	12.7	47.1	13.5	46.9	14.2	46.9	14.3	46.6	15.1	49
50	48.5	12.1	48.3	12.9	48.1	13.8	47.8	14.5	47.8	14.6	47.5	15.4	50
	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	De	Lat.	Dep.	Lat.	
Dist.	6 $\frac{3}{4}$ Point.		75 Deg.		74 Deg.		6 $\frac{2}{1}$ Point.		73 Deg.		72 Deg.		Dist.

Dist.	1¼ Point.		15 Deg.		16 Deg.		1½ Point.		17 Deg.		18 Deg.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.5	12.4	49.3	13.2	49.0	14.0	48.8	14.8	48.8	14.9	48.5	15.8	51
52	50.4	12.6	50.2	13.5	49.9	14.3	49.7	15.1	49.7	15.2	49.4	16.1	52
53	51.4	12.9	51.2	13.7	50.9	14.6	50.7	15.3	50.7	15.5	50.4	16.4	53
54	52.4	13.1	52.2	14.0	51.9	14.9	51.7	15.7	51.6	15.8	51.3	16.7	54
55	53.3	13.4	53.1	14.2	52.9	15.2	52.6	16.0	52.6	16.1	52.3	17.0	55
56	54.3	13.6	54.1	14.5	53.8	15.4	53.6	16.2	53.6	16.4	53.3	17.3	56
57	55.3	13.8	55.1	14.8	54.8	15.7	54.5	16.5	54.5	16.7	54.2	17.6	57
58	56.3	14.1	56.0	15.0	55.7	16.0	55.5	16.8	55.5	17.0	55.2	17.9	58
59	57.3	14.3	57.0	15.3	56.7	16.3	56.5	17.1	56.5	17.2	56.1	18.2	59
60	58.2	14.6	58.0	15.5	57.7	16.5	57.4	17.4	57.4	17.5	57.1	18.5	60
61	59.2	14.8	58.9	15.8	58.6	16.8	58.4	17.7	58.4	17.8	58.0	18.8	61
62	60.1	15.1	59.9	16.1	59.6	17.1	59.3	18.0	59.3	18.1	59.0	19.2	62
63	61.1	15.3	60.8	16.3	60.5	17.4	60.3	18.3	60.2	18.4	59.9	19.5	63
64	62.1	15.5	61.8	16.6	61.5	17.6	61.2	18.6	61.2	18.7	60.9	19.8	64
65	63.0	15.8	62.8	16.8	62.5	17.9	62.2	18.9	62.2	19.0	61.8	20.1	65
66	64.0	16.0	63.7	17.1	63.4	18.2	63.2	19.2	63.1	19.3	62.8	20.4	66
67	65.0	16.3	64.7	17.4	64.4	18.5	64.1	19.4	64.1	19.6	63.7	20.7	67
68	66.0	16.5	65.7	17.6	65.4	18.7	65.1	19.7	65.0	19.9	64.7	21.0	68
69	66.9	16.8	66.6	17.9	66.3	19.0	66.0	20.0	66.0	20.2	65.6	21.3	69
70	67.9	17.0	67.6	18.1	67.3	19.3	67.0	20.3	66.9	20.5	66.6	21.6	70
71	68.9	17.2	68.6	18.3	68.2	19.6	67.9	20.6	67.9	20.8	67.5	21.9	71
72	69.8	17.5	69.5	18.6	69.2	19.8	68.9	20.9	68.8	21.0	68.5	22.2	72
73	70.8	17.7	70.5	18.9	70.2	20.1	69.8	21.2	69.8	21.3	69.4	22.6	73
74	71.8	18.0	71.5	19.1	71.1	20.4	70.8	21.5	70.8	21.6	70.4	22.9	74
75	72.7	18.2	72.4	19.4	72.1	20.7	71.8	21.8	71.7	21.9	71.3	23.2	75
76	73.7	18.5	73.4	19.7	73.0	20.9	72.7	22.1	72.7	22.2	72.3	23.5	76
77	74.7	18.7	74.4	19.9	74.0	21.2	73.7	22.3	73.6	22.5	73.2	23.8	77
78	75.7	18.9	75.3	20.2	75.0	21.5	74.6	22.6	74.6	22.8	74.2	24.1	78
79	76.6	19.2	76.3	20.4	75.9	21.8	75.6	22.9	75.5	23.1	75.1	24.4	79
80	77.6	19.4	77.3	20.7	76.9	22.0	76.6	23.2	76.5	23.4	76.1	24.7	80
81	78.6	19.7	78.2	21.0	77.9	22.3	77.5	23.5	77.5	23.7	77.0	25.0	81
82	79.5	19.9	79.2	21.2	78.8	22.6	78.5	23.8	78.4	24.0	78.0	25.3	82
83	80.5	20.3	80.2	21.5	79.8	22.9	79.4	24.1	79.4	24.3	78.9	25.6	83
84	81.5	20.5	81.1	21.7	80.8	23.1	80.4	24.4	80.3	24.5	79.9	26.0	84
85	82.4	20.7	82.1	22.0	81.7	23.4	81.3	24.7	81.3	24.8	80.8	26.3	85
86	83.4	20.9	83.1	22.3	82.7	23.7	82.3	25.0	82.2	25.1	81.8	26.6	86
87	84.4	21.1	84.0	22.5	83.6	24.0	83.3	25.2	83.2	25.4	82.7	26.9	87
88	85.4	21.4	85.0	22.8	84.6	24.2	84.2	25.5	84.1	25.7	83.7	27.2	88
89	86.3	21.6	86.0	23.0	85.6	24.5	85.2	25.8	85.1	26.0	84.6	27.5	89
90	87.3	21.9	87.0	23.3	86.5	24.8	86.1	26.1	86.1	26.3	85.6	27.8	90
91	88.3	22.1	87.9	23.5	87.5	25.1	87.1	26.4	87.0	26.6	86.5	28.1	91
92	89.2	22.4	88.9	23.8	88.4	25.3	88.0	26.7	88.0	26.9	87.5	28.4	92
93	90.2	22.6	89.8	24.1	89.4	25.5	89.0	27.0	88.9	27.2	88.4	28.7	93
94	91.2	22.8	90.8	24.3	90.4	25.9	90.0	27.3	89.9	27.5	89.4	29.0	94
95	92.1	23.1	91.8	24.6	91.3	26.2	90.9	27.6	90.8	27.8	90.3	29.3	95
96	93.1	23.3	92.7	24.8	92.3	26.4	91.9	27.9	91.8	28.1	91.3	29.7	96
97	94.1	23.5	93.7	25.1	93.2	26.7	92.8	28.2	92.8	28.4	92.3	30.0	97
98	95.1	23.8	94.7	25.4	94.2	27.0	93.8	[illegible]	93.7	28.6	93.2	30.3	98
99	96.0	24.1	95.6	25.6	95.2	27.3	94.7	28.7	94.7	28.9	94.2	30.6	99
100	97.0	24.3	96.6	25.9	96.1	27.6	95.7	29.0	95.6	29.2	95.1	30.9	100
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	6¾ Point.		75 Deg.		74 Deg.		6½ Point.		73 Deg.		72 Deg.		

Dist.	19 Deg. Lat.	19 Deg. Dep.	1¾ Point. Lat.	1¾ Point. Dep.	20 Deg. Lat.	20 Deg. Dep.	21 Deg. Lat.	21 Deg. Dep.	22 Deg. Lat.	22 Deg. Dep.	2 Points Lat.	2 Points Dep.	Dist.
1	00.9	00.3	00.9	00.3	00.9	00.3	00.9	00.4	00.9	00.4	00.9	00.4	1
2	01.9	00.6	01.9	00.7	01.9	00.7	01.9	00.7	01.8	00.7	01.8	00.8	2
3	02.8	01.0	02.8	01.0	02.8	01.0	02.8	01.0	02.8	01.1	02.8	01.1	3
4	03.8	01.3	03.8	01.3	03.8	01.4	03.7	01.4	03.7	01.5	03.7	01.5	4
5	04.7	01.6	04.7	01.7	04.7	01.7	04.7	01.8	04.6	01.9	04.6	01.9	5
6	05.7	01.9	05.6	02.0	05.6	02.0	05.6	02.1	05.6	02.2	05.5	02.3	6
7	06.6	02.3	06.6	02.4	06.6	02.4	06.5	02.5	06.5	02.6	06.5	02.7	7
8	07.6	02.6	07.5	02.7	07.5	02.7	07.5	02.9	07.4	03.0	07.4	03.1	8
9	08.5	02.9	08.5	03.0	08.5	03.1	08.4	03.2	08.3	03.4	08.3	03.4	9
10	09.5	03.3	09.4	03.4	09.4	03.4	09.3	03.6	09.3	03.7	09.2	03.8	10
11	10.4	03.6	10.4	03.7	10.3	03.8	10.3	03.9	10.2	04.1	10.2	04.2	11
12	11.3	03.9	11.3	04.0	11.3	04.1	11.2	04.3	11.1	04.5	11.1	04.6	12
13	12.3	04.2	12.2	04.4	12.2	04.4	12.1	04.7	12.0	04.9	12.0	05.0	13
14	13.2	04.6	13.2	04.7	13.2	04.8	13.1	05.0	13.0	05.2	12.9	05.4	14
15	14.2	04.9	14.1	05.1	14.1	05.1	14.0	05.4	13.9	05.6	13.9	05.7	15
16	15.1	05.2	15.1	05.4	15.0	05.4	14.9	05.7	14.8	06.0	14.8	06.1	16
17	16.1	05.5	16.0	05.7	16.0	05.8	15.9	06.1	15.8	06.4	15.7	06.5	17
18	17.0	05.9	16.9	06.1	16.9	06.3	16.8	06.4	16.7	06.7	16.6	06.8	18
19	18.0	06.1	17.9	06.4	17.9	06.5	17.7	06.8	17.6	07.1	17.6	07.3	19
20	18.9	06.5	18.9	06.7	18.8	06.8	18.7	07.2	18.5	07.5	18.5	07.6	20
21	19.9	06.8	19.8	07.1	19.7	07.2	19.6	07.5	19.5	07.9	19.4	08.0	21
22	20.8	07.2	20.7	07.4	20.7	07.5	20.5	07.9	20.4	08.2	20.3	08.4	22
23	21.7	07.5	21.7	07.7	21.6	07.9	21.5	08.2	21.3	08.6	21.2	08.8	23
24	22.7	07.8	22.6	08.1	22.5	08.2	22.4	08.6	22.3	09.0	22.2	09.2	24
25	23.6	08.1	23.5	08.4	23.5	08.5	23.3	09.0	23.2	09.5	23.1	09.6	25
26	24.6	08.5	24.5	08.8	24.4	08.9	24.3	09.3	24.1	09.7	24.0	09.9	26
27	25.5	08.8	25.4	09.1	25.4	09.2	25.2	09.7	25.0	10.1	24.9	10.3	27
28	26.5	09.1	26.4	09.4	26.3	09.6	26.1	10.0	26.0	10.5	25.9	10.7	28
29	27.4	09.4	27.3	09.8	27.2	09.9	27.1	10.4	26.9	10.9	26.8	11.1	29
30	28.4	09.8	28.2	10.1	28.2	10.3	28.0	10.7	27.8	11.2	27.7	11.5	30
31	29.3	10.1	29.2	10.4	29.1	10.6	28.9	11.1	28.7	11.6	28.6	11.9	31
32	30.3	10.4	30.1	10.8	30.1	10.9	29.8	11.5	29.7	12.0	29.6	12.2	32
33	31.2	10.7	31.1	11.1	31.0	11.3	30.8	11.9	30.6	12.4	30.5	12.6	33
34	32.1	11.1	32.0	11.5	31.9	11.6	31.7	12.2	31.5	12.7	31.4	13.0	34
35	33.1	11.4	33.0	11.8	32.9	12.0	32.7	12.5	32.4	13.1	32.3	13.4	35
36	34.0	11.7	33.9	12.1	33.8	12.3	33.6	12.9	33.4	13.5	33.3	13.8	36
37	35.0	12.1	34.8	12.5	34.8	12.6	34.5	13.3	34.3	13.9	34.2	14.2	37
38	35.9	12.4	35.8	12.8	35.7	13.0	35.5	13.6	35.2	14.2	35.1	14.5	38
39	36.9	12.6	36.7	13.1	36.6	13.3	36.4	14.0	36.2	14.6	36.0	14.9	39
40	37.8	13.0	37.7	13.5	37.6	13.7	37.3	14.3	37.1	15.0	36.9	15.3	40
41	38.8	13.3	38.6	13.8	38.5	14.0	38.3	14.7	38.0	15.3	37.9	15.7	41
42	39.7	13.7	39.5	14.1	39.5	14.4	39.2	15.1	38.9	15.7	38.8	16.1	42
43	40.7	14.0	40.5	14.5	40.4	14.7	40.1	15.4	39.9	16.1	39.7	16.5	43
44	41.6	14.3	41.4	14.8	41.3	15.0	41.1	15.8	40.8	16.5	40.6	16.8	44
45	42.6	14.6	42.4	15.2	42.3	15.4	42.0	16.1	41.7	16.8	41.6	17.2	45
46	43.5	15.0	43.3	15.5	43.2	15.7	42.9	16.5	42.6	17.2	42.5	17.6	46
47	44.4	15.3	44.2	15.8	44.2	16.1	43.9	16.8	43.6	17.6	43.4	18.0	47
48	45.4	15.6	45.2	16.2	45.1	16.4	44.8	17.2	44.5	18.0	44.3	18.4	48
49	46.3	15.9	46.1	16.5	46.0	16.8	45.7	17.6	45.4	18.3	45.3	18.7	49
50	47.3	16.3	47.1	16.8	47.0	17.1	46.7	17.9	46.4	18.7	46.2	19.1	50
Dist.	Dep	Lat.	Dep	Lat.	Dep	Lat.	Dep.	Lat.	Dep	Lat.	Dep	Lat.	Dist.
	71 Deg.		6¼ Point.		70 Deg.		69 Deg.		68 Deg.		6 Points.		

Dist.	19 Deg.		1¾ Point.		20 Deg.		21 Deg.		22 Deg.		2 Point.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	48.2	16.6	48.0	17.2	47.9	17.4	47.6	18.3	47.3	19.1	47.1	19.5	51
52	49.2	16.9	49.0	17.5	48.9	17.8	48.5	18.6	48.2	19.4	48.0	19.9	52
53	50.1	17.3	49.9	17.9	49.8	18.1	49.5	19.0	49.1	19.8	49.0	20.3	53
54	51.1	17.6	50.8	18.2	50.7	18.5	50.4	19.3	50.1	20.2	49.9	20.7	54
55	52.0	17.9	51.8	18.5	51.7	18.8	51.3	19.7	51.0	20.6	50.8	21.0	55
56	52.9	18.2	52.7	18.9	52.6	19.2	52.3	20.1	51.9	21.0	51.7	21.4	56
57	53.9	18.6	53.7	19.2	53.6	19.5	53.2	20.4	52.8	21.3	52.7	21.8	57
58	54.8	18.9	54.6	19.5	54.5	19.8	54.1	20.8	53.8	21.7	53.6	22.2	58
59	55.8	19.2	55.5	19.9	55.4	20.2	55.1	21.1	54.7	22.1	54.5	22.6	59
60	56.7	19.5	56.5	20.2	56.4	20.5	56.0	21.5	55.6	22.5	55.4	23.0	60
61	57.7	19.9	57.4	20.5	57.3	20.9	56.9	21.9	56.5	22.8	56.3	23.3	61
62	58.6	20.2	58.4	20.9	58.3	21.0	57.9	22.2	57.5	23.2	57.3	23.7	62
63	59.6	20.5	59.3	21.2	59.2	21.5	58.8	22.6	58.4	23.6	58.2	24.1	63
64	60.5	20.8	60.3	21.6	60.1	21.9	59.7	22.9	59.3	24.0	59.1	24.5	64
65	61.5	21.2	61.2	21.9	61.1	22.2	60.7	23.3	60.3	24.3	60.0	24.9	65
66	62.4	21.5	62.1	22.2	62.0	22.6	61.6	23.6	61.2	24.7	61.0	25.3	66
67	63.3	21.8	63.1	22.6	63.0	22.9	62.5	24.0	62.1	25.1	61.9	25.6	67
68	64.3	22.1	64.0	22.9	63.9	23.3	63.5	24.4	63.0	25.5	62.8	26.0	68
69	65.2	22.5	65.0	23.2	64.8	23.6	64.4	24.7	64.0	25.8	63.7	26.4	69
70	66.2	22.8	65.9	23.6	65.8	23.9	65.3	25.1	64.9	26.2	64.7	26.8	70
71	67.1	23.1	66.8	23.9	66.7	24.3	66.3	25.4	65.8	26.6	65.6	27.2	71
72	68.1	23.4	67.8	24.2	67.7	24.6	67.2	25.8	66.7	27.0	66.5	27.6	72
73	69.0	23.8	68.7	24.5	68.6	25.0	68.1	26.2	67.7	27.3	67.4	27.9	73
74	70.0	24.1	69.7	24.9	69.6	25.3	69.1	26.5	68.6	27.7	68.4	28.3	74
75	70.9	24.4	70.6	25.3	70.5	25.6	70.0	26.9	69.5	28.1	69.3	28.7	75
76	71.9	24.7	71.6	25.6	71.4	26.0	70.9	27.2	70.5	28.5	70.2	29.1	76
77	72.8	25.1	72.5	25.9	72.4	26.3	71.9	27.6	71.4	28.8	71.1	29.5	77
78	73.7	25.4	73.4	26.3	73.3	26.7	72.8	27.9	72.3	29.2	72.1	29.8	78
79	74.7	25.7	74.4	26.6	74.2	27.0	73.7	28.3	73.2	29.6	73.0	30.2	79
80	75.6	26.0	75.3	26.9	75.2	27.4	74.7	28.7	74.2	30.0	73.9	30.6	80
81	76.6	26.4	76.3	27.3	76.1	27.7	75.6	29.0	75.1	30.3	74.8	31.0	81
82	77.5	26.7	77.2	27.6	77.1	28.0	76.5	29.4	76.0	30.7	75.8	31.4	82
83	78.5	27.0	78.1	28.0	78.0	28.4	77.5	29.7	76.9	31.1	76.7	31.8	83
84	79.4	27.3	79.1	28.3	78.9	28.7	78.4	30.1	77.9	31.5	77.6	32.1	84
85	80.4	27.7	80.1	28.6	79.9	29.1	79.3	30.5	78.8	31.8	78.6	32.5	85
86	81.3	28.0	81.0	29.0	80.8	29.4	80.3	30.8	79.7	32.2	79.4	32.9	86
87	82.3	28.3	81.9	29.3	81.8	29.7	81.2	31.2	80.7	32.6	80.4	33.3	87
88	83.2	28.6	82.8	29.6	82.7	30.1	82.1	31.5	81.6	33.0	81.3	33.7	88
89	84.1	29.0	83.8	30.0	83.6	30.4	83.1	31.9	82.5	33.3	82.2	34.1	89
90	85.1	29.3	84.7	30.3	84.6	30.8	84.0	32.3	83.4	33.7	83.1	34.4	90
91	86.0	29.6	85.7	30.7	85.5	31.1	84.9	32.6	84.4	34.1	84.1	34.8	91
92	87.0	29.9	86.6	31.0	86.4	31.5	85.9	33.0	85.3	34.5	85.0	35.2	92
93	88.0	30.3	87.6	31.3	87.4	31.8	86.8	33.3	86.2	34.8	85.9	35.6	93
94	88.9	30.6	88.5	31.7	88.3	32.1	87.7	33.7	87.2	35.2	86.8	36.0	94
95	89.8	30.9	89.4	32.0	89.3	32.5	88.7	34.0	88.1	35.6	87.8	36.3	95
96	90.8	31.3	90.4	32.3	90.2	32.8	89.6	34.4	89.0	35.9	88.9	36.7	96
97	91.7	31.6	91.3	32.7	91.1	33.2	90.5	34.8	89.9	36.3	89.6	37.1	97
98	92.7	31.9	92.3	33.0	92.1	33.5	91.5	35.1	90.9	36.7	90.5	37.5	98
99	93.6	32.2	93.2	33.3	93.0	33.9	92.4	35.5	91.8	37.1	91.5	37.9	99
100	94.5	32.6	94.2	33.7	94.0	34.2	93.4	35.8	92.7	37.5	92.4	38.3	100
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	71 Deg.		6¼ Point.		70 Deg.		69 Deg.		68 Deg.		6 Point.		

Dist.	23 Deg Lat.	23 Deg Dep	24 Deg. Lat.	24 Deg. Dep	25 Deg. Lat.	25 Deg. Dep.	2¼ Point. Lat.	2¼ Point. Dep	26 Deg. Lat.	26 Deg. Dep	27 Deg Lat.	27 Deg Dep
1	00.9	00.4	00.9	00.4	00.9	00.4	00.9	00.4	00.9	00.4	00.9	00.4
2	01.8	00.8	01.8	00.8	01.8	00.8	01.8	00.9	01.8	00.9	01.8	00.9
3	02.8	01.2	02.7	01.2	02.7	01.3	02.7	01.3	02.7	01.3	02.7	01.4
4	03.7	01.6	03.6	01.6	03.6	01.7	03.6	01.7	03.6	01.7	03.6	01.8
5	04.6	01.9	04.6	02.0	04.5	02.1	04.5	02.1	04.5	02.2	04.5	02.3
6	05.5	02.3	05.5	02.4	05.4	02.5	05.4	02.6	05.4	02.6	05.3	02.7
7	06.4	02.7	06.4	02.8	06.3	03.0	06.3	03.0	06.3	03.1	06.2	03.2
8	07.4	03.1	07.3	03.2	07.2	03.4	07.2	03.4	07.2	03.5	07.1	03.6
9	08.3	03.5	08.2	03.7	08.2	03.8	08.1	03.8	08.1	03.9	08.0	04.1
10	09.2	03.9	09.1	04.1	09.1	04.2	09.0	04.3	09.0	04.4	08.9	04.5
11	10.1	04.3	10.0	04.5	10.0	04.6	09.9	04.7	09.9	04.8	09.8	05.0
12	11.0	04.7	11.0	04.9	10.9	05.1	10.8	05.1	10.8	05.3	10.7	05.4
13	12.0	05.1	11.9	05.3	11.8	05.5	11.7	05.6	11.7	05.7	11.6	05.8
14	12.9	05.5	12.8	05.7	12.7	05.9	12.7	05.9	12.6	06.1	12.5	06.4
15	13.8	05.9	13.7	06.1	13.6	06.3	13.6	06.4	13.5	06.6	13.4	06.8
16	14.7	06.2	14.6	06.5	14.5	06.8	14.5	06.6	14.4	07.0	14.3	07.3
17	15.6	06.6	15.5	06.9	15.4	07.2	15.4	07.3	15.3	07.4	15.1	07.7
18	10.6	07.0	16.4	07.3	16.3	07.6	16.3	07.7	16.2	07.9	16.0	08.2
19	17.5	07.4	17.4	07.7	17.2	08.0	17.2	08.1	17.1	08.3	16.9	08.6
20	18.4	07.8	18.3	08.1	18.1	08.4	18.1	08.5	18.0	08.8	17.8	09.1
21	19.3	08.2	19.2	08.5	19.0	08.9	19.0	09.0	18.9	09.2	18.7	09.5
22	20.2	08.6	20.1	08.9	19.9	09.3	19.9	09.4	19.8	09.9	19.6	10.0
23	21.2	09.0	21.0	09.3	20.8	09.7	20.8	09.8	20.7	10.1	20.5	10.4
24	22.1	09.4	21.9	09.8	21.7	10.1	21.7	10.3	21.6	10.5	21.4	10.9
25	23.0	09.8	22.8	10.2	22.7	10.6	22.6	10.7	22.5	11.0	22.3	11.3
26	23.9	10.2	23.7	10.6	23.6	11.0	23.5	11.1	23.4	11.4	23.2	11.8
27	24.8	10.5	24.7	11.0	24.5	11.4	24.4	11.5	24.3	11.8	24.1	12.2
28	25.8	10.9	25.6	11.4	25.4	11.8	25.2	12.0	25.2	12.3	24.9	12.7
29	26.7	11.3	26.5	11.8	26.3	12.3	26.2	12.4	26.1	12.7	25.8	13.2
30	27.6	11.7	27.4	12.2	27.2	12.7	27.1	12.8	27.0	13.1	26.7	13.6
31	28.5	12.1	28.3	12.6	28.1	13.1	28.0	13.3	27.9	13.6	27.6	14.1
32	29.5	12.5	29.2	13.0	29.0	13.5	28.9	13.7	28.8	14.0	28.5	14.5
33	30.4	12.9	30.1	13.4	29.9	13.9	29.8	14.1	29.7	14.4	29.4	15.0
34	31.3	13.3	31.1	13.8	30.8	14.4	30.7	14.5	30.6	14.9	30.3	15.4
35	32.2	13.7	32.0	14.2	31.7	14.8	31.6	15.0	31.5	15.3	31.2	15.9
36	33.1	14.1	32.9	14.6	32.6	15.2	32.5	15.4	32.4	15.8	32.1	16.3
37	34.1	14.4	33.8	15.0	33.5	15.6	33.4	15.8	33.2	16.2	33.0	16.8
38	35.0	14.8	34.7	15.4	34.4	16.0	34.3	16.2	34.1	16.6	33.9	17.2
39	35.9	15.2	35.6	15.9	35.3	16.5	35.3	16.7	35.0	17.1	34.7	17.7
40	36.8	15.6	36.5	16.3	36.2	16.9	36.2	17.1	35.9	17.5	35.6	18.2
41	37.7	16.0	37.5	16.7	37.2	17.3	37.1	17.5	36.8	18.0	36.5	18.6
42	38.7	16.4	38.4	17.1	38.1	17.7	38.0	18.0	37.7	18.4	37.4	19.1
43	39.6	16.8	39.3	17.5	39.0	18.2	38.9	18.4	38.6	18.8	38.3	19.5
44	40.5	17.2	40.2	17.9	39.9	18.6	39.8	18.8	39.5	19.3	39.2	20.0
45	41.4	17.6	41.1	18.3	40.8	19.0	40.7	19.2	40.4	19.7	40.1	20.4
46	42.3	18.0	42.0	18.7	41.7	19.4	41.6	19.7	41.3	20.2	41.0	20.9
47	43.3	18.4	42.9	19.1	42.6	19.9	42.5	20.1	42.2	20.6	41.9	21.3
48	44.2	18.8	43.8	19.5	43.5	20.3	43.4	20.5	43.1	21.0	42.8	21.8
49	45.1	19.2	44.8	19.9	44.4	20.7	44.3	20.9	44.0	21.5	43.7	22.2
50	46.0	19.5	45.7	20.3	45.3	21.1	45.2	21.4	44.9	21.9	44.5	22.7
Dist.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	67 Deg.		66 Deg.		65 Deg.		5¾ Point.		64 Deg.		63 Deg.	

Dist.	23 Deg.		24 Deg.		25 Deg		2¼ Point		26 Deg		27 Deg.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	46.9	19.9	46.6	20.7	46.2	21.5	46.1	21.8	45.8	22.3	45.4	23.2	51
52	47.9	20.3	47.5	21.1	47.1	22.0	47.0	22.2	46.7	22.8	46.3	23.5	52
53	48.8	20.7	48.4	21.5	48.0	22.4	47.9	22.7	47.6	23.2	47.2	24.1	53
54	49.7	21.1	49.3	22.0	48.9	22.8	48.8	23.1	48.5	23.7	48.1	24.5	54
55	50.6	21.5	50.2	22.4	49.8	23.2	49.7	23.5	49.4	24.1	49.0	25.0	55
56	51.5	21.9	51.2	22.8	50.7	23.7	50.6	23.9	50.3	24.5	49.9	25.4	56
57	52.5	22.3	52.1	23.2	51.7	24.1	51.5	24.4	51.2	25.0	50.8	25.9	57
58	53.4	22.7	53.0	23.6	52.6	24.5	52.4	24.8	52.1	25.4	51.7	26.3	58
59	54.3	23.0	53.9	24.0	53.5	24.9	53.3	25.2	53.0	25.9	52.6	26.8	59
60	55.2	23.4	54.8	24.4	54.4	25.4	54.2	25.6	53.9	26.3	53.5	27.2	60
61	56.1	23.8	55.7	24.8	55.3	25.8	55.1	26.1	54.8	26.7	54.4	27.7	61
62	57.1	24.2	56.6	25.2	56.2	26.2	56.0	26.5	55.7	27.2	55.2	28.1	62
63	58.0	24.6	57.5	25.6	57.1	26.6	56.9	26.9	56.6	27.6	56.1	28.6	63
64	58.9	25.0	58.5	26.0	58.0	27.0	57.9	27.4	57.5	28.0	57.0	29.1	64
65	59.8	25.4	59.4	26.4	58.9	27.5	58.8	27.8	58.4	28.5	57.9	29.5	65
66	60.7	25.8	60.3	26.8	59.8	27.9	59.7	28.2	59.3	28.9	58.8	30.0	66
67	61.7	26.2	61.2	27.2	60.7	28.3	60.6	28.6	60.2	29.4	59.7	30.4	67
68	62.6	26.6	62.1	27.7	61.6	28.7	61.5	29.1	61.1	29.8	60.6	30.9	68
69	63.5	27.0	63.0	28.1	62.5	29.2	62.4	29.5	62.0	30.2	61.5	31.5	69
70	64.4	27.3	63.9	28.5	63.4	29.6	63.3	29.9	62.9	30.7	62.4	31.8	70
71	65.4	27.7	64.9	28.9	64.3	30.0	64.2	30.4	63.8	31.1	63.3	32.2	71
72	66.3	28.1	65.8	29.3	65.2	30.4	65.1	30.8	64.7	31.6	64.2	32.7	72
73	67.2	28.5	66.7	29.7	66.2	30.8	66.0	31.2	65.6	32.0	65.0	33.1	73
74	68.1	28.9	67.6	30.1	67.1	31.3	66.9	31.6	66.5	32.4	65.9	33.6	74
75	69.0	29.3	68.5	30.5	68.0	31.7	67.8	32.1	67.4	32.9	66.8	34.1	75
76	70.0	29.7	69.4	30.9	68.9	32.1	68.7	32.5	68.3	33.3	67.7	34.5	76
77	70.9	30.1	70.3	31.3	69.8	32.5	69.6	32.9	69.2	33.7	68.6	35.0	77
78	71.8	30.5	71.2	31.7	70.7	33.0	70.5	33.3	70.1	34.2	69.5	35.4	78
79	72.7	30.9	72.2	32.1	71.6	33.5	71.4	33.8	71.0	34.6	70.4	35.9	79
80	73.6	31.3	73.1	32.5	72.5	33.8	72.3	34.2	71.9	35.1	71.3	36.3	80
81	74.6	31.6	74.0	32.9	73.4	34.2	73.2	34.6	72.8	35.5	72.2	36.8	81
82	75.5	32.0	74.9	33.3	74.3	34.7	74.1	35.1	73.7	35.9	73.1	37.2	82
83	76.4	32.4	75.8	33.8	75.2	35.1	75.0	35.5	74.6	36.4	74.0	37.7	83
84	77.3	32.8	76.7	34.2	76.1	35.5	75.9	35.9	75.5	36.8	74.8	38.1	84
85	78.2	33.2	77.6	34.6	77.0	35.9	76.8	36.3	76.4	37.3	75.7	38.6	85
86	79.2	33.6	78.6	35.0	77.9	36.3	77.7	36.8	77.3	37.7	76.6	39.0	86
87	80.1	34.0	79.5	35.4	78.8	36.8	78.6	37.2	78.2	38.1	77.5	39.5	87
88	81.0	34.4	80.4	35.8	79.7	37.2	79.5	37.6	79.1	38.6	78.4	40.0	88
89	81.9	34.8	81.3	36.2	80.7	37.6	80.5	38.1	80.0	39.0	79.3	40.4	89
90	82.8	35.2	82.2	36.6	81.6	38.0	81.4	38.5	80.9	39.4	80.2	40.9	90
91	83.7	35.6	83.1	37.0	82.5	38.5	82.3	38.9	81.8	39.8	81.1	41.1	91
92	84.7	35.9	84.0	37.4	83.4	38.9	83.2	39.3	82.7	40.3	82.0	41.8	92
93	85.6	36.3	85.0	37.8	84.3	39.3	84.1	39.8	83.6	40.8	82.9	42.2	93
94	86.5	36.7	85.9	38.2	85.2	39.7	85.0	40.2	84.5	41.2	83.8	42.7	94
95	87.4	37.1	86.8	38.6	86.1	40.1	85.9	40.6	85.4	41.6	84.6	43.1	95
96	88.4	37.5	87.7	39.0	87.0	40.6	86.8	41.0	86.3	42.1	85.5	43.6	96
97	89.3	37.9	88.6	39.4	87.9	41.0	87.7	41.5	87.2	42.5	86.4	44.0	97
98	90.2	38.3	89.5	39.9	88.8	41.4	88.6	41.9	88.1	43.0	87.3	44.4	98
99	91.1	38.7	90.4	40.3	89.7	41.8	89.5	42.3	89.0	43.4	88.2	44.9	99
100	92.0	39.1	91.4	40.7	90.6	42.3	90.4	42.7	89.9	43.8	89.1	45.4	100
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	67 Deg.		66 Deg.		65 Deg.		5¾ Point.		64 Deg.		63 Deg.		

Dist.	28 Deg.		2½ Point.		29 Deg.		30 Deg.		2¾ Point.		31 Deg.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	00.9	00.5	00.9	00.5	00.9	00.5	00.9	00.5	00.9	00.5	00.9	00.5	1
2	01.8	00.9	01.8	00.9	01.7	01.0	01.7	01.0	01.7	01.0	01.7	01.0	2
3	02.6	01.4	02.6	01.4	02.6	01.4	02.6	01.5	02.6	01.5	02.6	01.5	3
4	03.5	01.9	03.5	01.9	03.5	01.9	03.5	02.0	03.4	02.1	03.4	02.1	4
5	04.4	02.3	04.4	02.4	04.4	02.4	04.3	02.5	04.3	02.6	04.3	02.6	5
6	05.3	02.8	05.3	02.8	05.2	02.9	05.2	03.0	05.1	03.1	05.1	03.1	6
7	06.2	03.3	06.2	03.3	06.1	03.4	06.1	03.5	06.0	03.6	06.1	03.6	7
8	07.1	03.8	07.1	03.8	07.0	03.9	07.0	04.0	06.9	04.1	06.9	04.1	8
9	07.9	04.2	07.9	04.2	07.9	04.4	07.8	04.5	07.7	04.6	07.7	04.6	9
10	08.8	04.7	08.8	04.7	08.7	04.8	08.7	05.0	08.6	05.1	08.6	05.1	10
11	09.7	05.2	09.7	05.2	09.6	05.3	09.5	05.5	09.4	05.6	09.4	05.7	11
12	10.6	05.6	10.6	05.6	10.5	05.8	10.4	06.0	10.3	06.2	10.3	06.2	12
13	11.5	06.1	11.5	06.1	11.4	06.3	11.3	06.5	11.1	06.7	11.1	06.7	13
14	12.3	06.6	12.3	06.6	12.2	06.8	12.1	07.0	12.0	07.2	12.0	07.2	14
15	13.2	07.0	13.2	07.1	13.1	07.3	13.0	07.5	12.9	07.7	12.9	07.7	15
16	14.1	07.5	14.1	07.5	14.0	07.7	13.9	08.0	13.7	08.2	13.7	08.2	16
17	15.0	08.0	15.0	08.0	14.9	08.2	14.7	08.5	14.6	08.7	14.6	08.8	17
18	15.9	08.4	15.9	08.5	15.7	08.7	15.6	09.0	15.4	09.2	15.4	09.3	18
19	16.8	08.9	16.8	08.9	16.6	09.2	16.4	09.5	16.3	09.8	16.3	09.8	19
20	17.7	09.4	17.6	09.4	17.5	09.7	17.3	10.0	17.1	10.3	17.1	10.3	20
21	18.5	09.9	18.5	09.9	18.4	10.2	18.2	10.5	18.0	10.8	18.0	10.8	21
22	19.4	10.3	19.4	10.3	19.2	10.7	19.0	11.0	18.9	11.3	18.9	11.3	22
23	20.3	10.8	20.3	10.8	20.1	11.1	19.9	11.5	19.7	11.8	19.7	11.8	23
24	21.2	11.3	21.2	11.3	21.0	11.6	20.8	12.0	20.6	12.3	20.6	12.4	24
25	22.1	11.7	22.0	11.8	21.9	12.1	21.6	12.5	21.4	12.8	21.4	12.9	25
26	23.0	12.3	22.9	12.3	22.7	12.6	22.5	13.0	22.3	13.4	22.3	13.4	26
27	23.8	12.7	23.8	12.7	23.6	13.1	23.4	13.5	23.1	13.9	23.1	13.9	27
28	24.7	13.1	24.7	13.2	24.5	13.6	24.2	14.0	24.0	14.4	24.0	14.4	28
29	25.6	13.6	25.6	13.7	25.4	14.1	25.1	14.5	24.9	14.9	24.9	14.9	29
30	26.5	14.1	26.5	14.1	26.2	14.5	26.0	15.0	25.7	15.4	25.7	15.4	30
31	27.4	14.5	27.3	14.6	27.1	15.0	26.8	15.5	26.6	15.9	26.6	16.0	31
32	28.2	15.0	28.2	15.1	28.0	15.5	27.7	16.0	27.4	16.4	27.4	16.5	32
33	29.1	15.6	29.1	15.5	28.9	16.0	28.6	16.5	28.3	17.0	28.3	17.0	33
34	30.0	16.0	30.0	16.0	29.7	16.5	29.5	17.0	29.2	17.5	29.1	17.5	34
35	30.9	16.4	30.9	16.5	30.6	17.0	30.3	17.5	30.0	18.0	30.0	18.0	35
36	31.8	16.9	31.7	17.0	31.5	17.4	31.2	18.0	30.9	18.5	30.9	18.5	36
37	32.7	17.4	32.6	17.4	32.4	17.9	32.0	18.5	31.7	19.0	31.7	19.1	37
38	33.5	17.9	33.5	17.9	33.2	18.4	32.9	19.0	32.5	19.5	32.6	19.6	38
39	34.4	18.3	34.4	18.4	34.1	18.9	33.8	19.5	33.4	20.0	33.4	20.1	39
40	35.3	18.8	35.3	18.9	35.0	19.4	34.6	20.0	34.3	20.6	34.3	20.6	40
41	36.2	19.2	36.1	19.3	35.8	19.9	35.5	20.5	35.2	21.1	35.1	21.1	41
42	37.1	19.7	37.0	19.8	36.7	20.4	36.4	21.0	36.0	21.6	36.0	21.6	42
43	38.0	20.1	37.9	20.3	37.6	20.8	37.2	21.5	36.9	22.1	36.9	22.1	43
44	38.8	20.6	38.8	20.7	38.5	21.3	38.1	22.0	37.7	22.6	37.7	22.6	44
45	39.7	21.1	39.7	21.2	39.3	21.8	39.0	22.5	38.6	23.1	38.6	23.2	45
46	40.6	21.6	40.6	21.7	40.2	22.3	39.8	23.0	39.5	23.6	39.4	23.7	46
47	41.5	22.1	41.4	22.2	41.1	22.8	40.7	23.5	40.3	24.2	40.3	24.2	47
48	42.4	22.5	42.3	22.6	42.0	23.3	41.6	24.0	41.2	24.7	41.1	24.7	48
49	43.3	23.1	43.2	23.2	42.8	23.7	42.4	24.5	42.0	25.2	42.0	25.2	49
50	44.1	23.5	44.1	23.6	43.7	24.2	43.3	25.0	42.9	25.7	42.9	25.7	50
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	62 Deg.		5½ Point.		61 Deg.		60 Deg.		5¼ Point.		59 Deg.		

Dist.	28 Deg.		2½ Point.		29 Deg.		30 Deg.		2¾ Point		31 Deg		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	45.0	23.9	45.0	24.0	44.6	24.7	44.2	25.5	43.7	26.2	43.7	26.3	51
52	45.9	24.4	45.9	24.5	45.5	25.2	45.0	26.0	44.6	26.7	44.6	26.8	52
53	46.8	24.9	46.7	25.0	46.3	25.7	45.9	26.5	45.5	27.2	45.4	27.3	53
54	47.7	25.3	47.6	25.5	47.2	26.2	46.8	27.0	46.3	27.8	46.3	27.8	54
55	48.6	25.8	48.5	25.9	48.1	26.7	47.6	27.5	47.2	28.3	47.1	28.3	55
56	49.4	26.3	49.4	26.4	49.0	27.1	48.5	28.0	48.0	28.8	48.0	28.8	56
57	50.3	26.8	50.3	26.9	49.8	27.6	49.4	28.5	48.9	29.3	48.9	29.4	57
58	51.2	27.2	51.2	27.3	50.7	28.1	50.2	29.0	49.7	29.8	49.7	29.9	58
59	52.1	27.7	52.0	27.8	51.6	28.6	51.1	29.5	50.6	30.3	50.6	30.4	59
60	53.0	28.2	52.9	28.3	52.5	29.1	52.0	30.0	51.5	30.8	51.4	30.9	60
61	53.9	28.6	53.8	28.7	53.3	29.6	52.8	30.5	52.3	31.4	52.3	31.4	61
62	54.7	29.1	54.7	29.2	54.2	30.1	53.7	31.0	53.2	31.9	53.1	31.9	62
63	55.6	29.6	55.6	29.7	55.1	30.5	54.6	31.5	54.0	32.4	54.0	32.4	63
64	56.5	30.0	56.4	30.2	56.0	31.0	55.4	32.0	54.9	32.9	54.9	33.0	64
65	57.4	30.5	57.3	30.5	56.8	31.5	56.3	32.5	55.7	33.4	55.7	33.5	65
66	58.3	31.0	58.2	31.1	57.7	32.0	57.2	33.0	56.6	33.9	56.6	34.0	66
67	59.2	31.4	59.1	31.6	58.6	32.5	58.0	33.5	57.5	34.4	57.4	34.5	67
68	60.0	31.9	60.0	32.0	59.5	33.0	58.9	34.0	58.3	35.0	58.3	35.0	68
69	60.9	32.4	60.8	32.5	60.3	33.4	59.7	34.5	59.2	35.5	59.1	35.5	69
70	61.8	32.9	61.7	33.0	61.2	33.9	60.6	35.0	60.0	36.0	60.0	36.0	70
71	62.7	33.3	62.6	33.5	62.1	34.4	61.5	35.5	60.9	36.5	60.9	36.6	71
72	63.6	33.8	63.5	33.9	63.0	34.9	62.3	36.0	61.8	37.0	61.7	37.1	72
73	64.4	34.3	64.4	34.4	63.8	35.4	63.2	36.5	62.6	37.5	62.6	37.6	73
74	65.3	34.7	65.3	34.9	64.7	35.9	64.1	37.0	63.5	38.0	63.4	38.1	74
75	66.2	35.2	66.1	35.4	65.6	36.4	64.9	37.5	64.3	38.6	64.3	38.6	75
76	67.1	35.7	67.0	35.8	66.5	36.8	65.8	38.0	65.2	39.1	65.1	39.1	76
77	68.0	36.1	67.9	36.3	67.3	37.3	66.7	38.5	66.0	39.6	66.0	39.7	77
78	68.9	36.6	68.8	36.8	68.2	37.8	67.5	39.0	66.9	40.1	66.9	40.2	78
79	69.7	37.1	69.7	37.2	69.1	38.3	68.4	39.5	67.8	40.6	67.7	40.7	79
80	70.6	37.6	70.5	37.7	70.0	38.8	69.3	40.0	68.6	41.1	68.6	41.2	80
81	71.5	38.0	71.4	38.2	70.8	39.3	70.1	40.5	69.5	41.6	69.4	41.7	81
82	72.4	38.5	72.3	38.6	71.7	39.7	70.9	41.0	70.3	42.2	70.3	42.2	82
83	73.3	39.0	73.2	39.1	72.6	40.2	71.9	41.5	71.2	42.7	71.1	42.7	83
84	74.2	39.4	74.1	39.6	73.5	40.7	72.7	42.0	72.1	43.2	72.0	43.3	84
85	75.0	39.9	75.0	40.1	74.3	41.2	73.6	42.5	72.9	43.7	72.9	43.8	85
86	75.9	40.4	75.8	40.5	75.2	41.7	74.5	43.0	73.8	44.2	73.7	44.3	86
87	76.8	40.8	76.7	41.0	76.1	42.2	75.3	43.5	74.6	44.7	74.6	44.8	87
88	77.7	41.3	77.6	41.5	77.0	42.7	76.2	44.0	75.5	45.2	75.4	45.3	88
89	78.6	41.8	78.5	41.9	77.8	43.1	77.1	44.5	76.3	45.8	76.3	45.8	89
90	79.5	42.2	79.4	42.4	78.7	43.6	77.9	45.0	77.2	46.3	77.1	46.3	90
91	80.3	42.7	80.2	42.9	79.6	44.1	78.8	45.5	78.1	46.8	78.0	46.9	91
92	81.2	43.2	81.1	43.4	80.5	44.6	79.7	46.0	78.9	47.3	78.9	47.4	92
93	82.1	43.6	82.0	43.8	81.3	45.1	80.5	46.5	79.8	47.8	79.7	47.9	93
94	83.0	44.1	82.9	44.3	82.2	45.6	81.4	47.0	80.6	48.3	80.6	48.4	94
95	83.9	44.6	83.8	44.8	83.1	46.1	82.3	47.5	81.5	48.8	81.4	48.9	95
96	84.8	45.1	84.7	45.2	84.0	46.5	83.1	48.0	82.3	49.3	82.3	49.4	96
97	85.6	45.5	85.5	45.7	84.8	47.0	84.0	48.5	83.2	49.9	83.1	50.0	97
98	86.5	46.0	86.4	46.2	85.7	47.5	84.9	49.0	84.1	50.4	84.0	50.5	98
99	87.4	46.5	87.3	46.7	86.6	48.0	85.7	49.5	84.9	50.9	84.9	51.0	99
100	88.3	46.9	88.2	47.1	87.5	48.5	86.6	50.0	85.8	51.4	85.7	51.5	100
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	62 Deg.		5½ Point		61 Deg.		60 Deg.		5¼ Point.		59 Deg.		

Dist.	32 Deg.		33 Deg.		3 Point		34 Deg.		35 Deg.		36 Deg.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	00.8	00.5	00.8	00.5	00.8	00.6	00.8	00.6	00.8	00.6	00.8	00.6	1
2	01.7	01.1	01.7	01.1	01.7	01.1	01.7	01.1	01.6	01.1	01.6	01.2	2
3	02.5	01.6	02.5	01.6	02.5	01.7	02.5	01.7	02.5	01.7	02.4	01.8	3
4	03.4	02.1	03.4	02.2	03.3	02.2	03.3	02.2	03.3	02.3	03.2	02.3	4
5	04.2	02.6	04.2	02.7	04.2	02.8	04.1	02.8	04.1	02.9	04.0	02.9	5
6	05.1	03.2	05.0	03.3	05.0	03.3	05.0	03.4	04.9	03.4	04.8	03.5	6
7	05.9	03.7	05.9	03.8	05.8	03.9	05.8	03.9	05.7	04.0	05.7	04.1	7
8	06.8	04.2	06.7	04.4	06.6	04.4	06.6	04.5	06.5	04.6	06.5	04.7	8
9	07.6	04.8	07.5	04.9	07.5	05.0	07.5	05.0	07.4	05.2	07.3	05.3	9
10	08.5	05.3	08.4	05.4	08.3	05.6	08.3	05.6	08.2	05.7	08.1	05.9	10
11	09.3	05.8	09.2	06.0	09.1	06.1	09.1	06.1	09.0	06.3	08.9	06.5	11
12	10.2	06.4	10.1	06.5	10.0	06.7	09.9	06.7	09.8	06.9	09.7	07.0	12
13	11.0	06.9	10.9	07.1	10.8	07.2	10.8	07.3	10.6	07.5	10.5	07.6	13
14	11.9	07.4	11.7	07.6	11.6	07.8	11.6	07.8	11.5	08.0	11.3	08.2	14
15	12.7	07.9	12.6	08.2	12.5	08.3	12.4	08.4	12.3	08.6	12.1	08.8	15
16	13.6	08.5	13.4	08.7	13.3	08.9	13.3	08.9	13.1	09.2	12.9	09.4	16
17	14.4	09.0	14.3	09.3	14.1	09.4	14.1	09.5	13.9	09.8	13.7	10.0	17
18	15.3	09.5	15.1	09.8	15.0	10.0	14.9	10.1	14.7	10.3	14.6	10.6	18
19	16.1	10.1	15.9	10.3	15.8	10.6	15.7	10.6	15.6	10.9	15.4	11.2	19
20	17.0	10.6	16.8	10.9	16.6	11.1	16.6	11.2	16.4	11.5	16.2	11.8	20
21	17.8	11.1	17.6	11.4	17.5	11.7	17.4	11.7	17.2	12.0	17.0	12.3	21
22	18.6	11.7	18.5	12.0	18.3	12.2	18.2	12.3	18.0	12.6	17.8	12.9	22
23	19.5	12.2	19.3	12.5	19.1	12.8	19.0	12.8	18.8	13.2	18.6	13.5	23
24	20.3	12.7	20.1	13.1	20.0	13.3	19.9	13.4	19.7	13.8	19.4	14.1	24
25	21.2	13.2	21.0	13.6	20.7	13.9	20.7	14.0	20.5	14.3	20.2	14.7	25
26	22.0	13.8	21.8	14.2	21.6	14.4	21.5	14.5	21.3	14.9	21.0	15.3	26
27	22.9	14.3	22.6	14.7	22.4	15.0	22.4	15.1	22.1	15.5	21.8	15.9	27
28	23.7	14.8	23.5	15.2	23.3	15.5	23.2	15.6	22.9	16.1	22.6	16.5	28
29	24.6	15.4	24.3	15.8	24.1	16.1	24.0	16.2	23.8	16.6	23.4	17.0	29
30	25.4	15.9	25.2	16.3	24.9	16.7	24.9	16.8	24.6	17.2	24.3	17.6	30
31	26.3	16.4	26.0	16.9	25.8	17.2	25.7	17.3	25.4	17.8	25.1	18.2	31
32	27.1	17.0	26.8	17.4	26.6	17.8	26.5	17.9	26.2	18.3	25.9	18.8	32
33	28.0	17.5	27.7	18.0	27.4	18.3	27.4	18.4	27.0	18.9	26.7	19.4	33
34	28.8	18.0	28.5	18.5	28.3	18.9	28.2	19.0	27.9	19.5	27.5	20.0	34
35	29.7	18.5	29.4	19.1	29.1	19.4	29.0	19.6	28.7	20.1	28.3	20.6	35
36	30.5	19.1	30.2	19.6	29.9	20.0	29.8	20.1	29.5	20.6	29.1	21.2	36
37	31.4	19.6	31.0	20.1	30.8	20.6	30.7	20.7	30.3	21.2	29.9	21.7	37
38	32.2	20.1	31.9	20.7	31.6	21.1	31.5	21.2	31.1	21.8	30.7	22.3	38
39	33.1	20.7	32.7	21.2	32.4	21.7	32.3	21.8	32.0	22.3	31.5	22.9	39
40	33.9	21.2	33.6	21.8	33.3	22.2	33.2	22.4	32.8	22.9	32.4	23.5	40
41	34.8	21.7	34.4	22.3	34.1	22.8	34.0	22.9	33.6	23.5	33.2	24.1	41
42	35.6	22.3	35.2	22.9	34.9	23.3	34.8	23.5	34.4	24.1	34.0	24.7	42
43	36.5	22.8	36.1	23.4	35.7	23.9	35.6	24.0	35.2	24.6	34.8	25.4	43
44	37.3	23.3	36.9	24.0	36.6	24.4	36.5	24.6	36.0	25.2	35.6	25.9	44
45	38.1	23.8	37.7	24.5	37.4	25.0	37.3	25.2	36.9	25.8	36.4	26.4	45
46	39.0	24.4	38.6	25.0	38.2	25.5	38.2	25.7	37.7	26.4	37.2	27.0	46
47	39.9	24.9	39.4	25.6	39.1	26.1	39.0	26.3	38.5	26.9	38.0	27.6	47
48	40.7	25.4	40.3	26.1	39.9	26.7	39.8	26.8	39.3	27.5	38.8	28.2	48
49	41.5	26.0	41.1	26.7	40.7	27.2	40.6	27.4	40.1	28.1	39.6	28.8	49
50	42.4	26.5	41.9	27.2	41.6	27.8	41.4	28.0	41.0	28.7	40.4	29.4	50
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	58 Deg.		57 Deg.		5 Point.		56 Deg.		55 Deg.		54 Deg.		

Dist.	32 Deg.		33 Deg.		3 Point.		34 Deg.		35 Deg.		36 Deg.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	43.2	27.0	42.8	27.8	42.4	28.3	42.3	28.5	41.8	29.2	41.3	30.0	51
52	44.1	27.6	43.6	28.3	43.2	28.9	43.1	29.1	42.6	29.8	42.1	30.6	52
53	44.9	28.1	44.5	28.9	44.1	29.4	43.9	29.6	43.4	30.4	42.9	31.2	53
54	45.8	28.6	45.3	29.4	44.9	30.0	44.8	30.2	44.2	31.0	43.7	31.7	54
55	46.6	29.1	46.1	30.0	45.7	30.6	45.6	30.7	45.1	31.5	44.5	32.3	55
56	47.5	29.7	47.0	30.5	46.6	31.1	46.4	31.3	45.9	32.1	45.3	32.9	56
57	48.3	30.2	47.8	31.0	47.4	31.7	47.3	31.9	46.7	32.7	46.1	33.5	57
58	49.2	30.7	48.7	31.6	48.2	32.2	48.1	32.4	47.5	33.3	46.9	34.1	58
59	50.0	31.3	49.5	32.1	49.0	32.8	48.9	33.0	48.3	33.8	47.7	34.7	59
60	50.9	31.8	50.3	32.7	49.9	33.3	49.7	33.5	49.1	34.4	48.5	35.3	60
61	51.7	32.3	51.2	33.2	50.7	33.9	50.6	34.1	50.0	34.9	49.3	35.9	61
62	52.6	32.9	52.0	33.8	51.5	34.4	51.4	34.7	50.8	35.6	50.2	36.4	62
63	53.4	33.4	52.9	34.3	52.4	35.0	52.2	35.3	51.6	36.1	51.0	37.0	63
64	54.3	33.9	53.7	34.9	53.2	35.5	53.1	35.8	52.4	36.7	51.8	37.6	64
65	55.1	34.4	54.5	35.4	54.0	36.1	53.9	36.3	53.2	37.3	52.6	38.1	65
66	56.0	35.0	55.3	35.9	54.9	36.7	54.7	36.9	54.1	37.9	53.4	38.8	66
67	56.8	35.5	56.2	36.5	55.7	37.2	55.5	37.5	54.9	38.4	54.2	39.4	67
68	57.7	36.0	57.0	37.0	56.5	37.8	56.4	38.0	55.7	39.0	55.0	40.0	68
69	58.5	36.6	57.9	37.6	57.4	38.3	57.2	38.6	56.5	39.6	55.8	40.6	69
70	59.4	37.1	58.7	38.1	58.2	38.9	58.0	39.1	57.3	40.1	56.6	41.1	70
71	60.2	37.6	59.6	38.7	59.0	39.4	58.9	39.7	58.2	40.7	57.4	41.7	71
72	61.0	38.1	60.4	39.2	59.8	40.0	59.7	40.3	59.0	41.3	58.2	42.3	72
73	61.9	38.7	61.2	39.8	60.7	40.6	60.5	40.8	59.8	41.9	59.1	42.9	73
74	62.7	39.2	62.1	40.3	61.5	41.1	61.3	41.4	60.6	42.4	59.9	43.5	74
75	63.6	39.7	62.9	40.8	62.4	41.7	62.2	41.9	61.1	43.0	60.7	44.1	75
76	64.4	40.3	63.8	41.5	63.2	42.2	63.0	42.5	62.3	43.6	61.5	44.7	76
77	65.3	40.8	64.6	41.9	64.0	42.8	63.8	43.0	63.1	44.2	62.3	45.3	77
78	66.1	41.3	65.4	42.5	64.8	43.3	64.7	43.6	63.9	44.7	63.1	45.8	78
79	67.0	41.9	66.3	43.0	65.7	43.9	65.5	44.2	64.7	45.3	63.9	46.4	79
80	67.8	42.4	67.1	43.6	66.5	44.4	66.3	44.7	65.5	45.9	64.7	47.0	80
81	68.7	42.9	68.0	44.1	67.3	45.0	67.1	45.3	66.4	46.5	65.5	47.6	81
82	69.5	43.4	68.8	44.7	68.2	45.5	68.0	45.8	67.2	47.0	66.3	48.2	82
83	70.4	44.0	69.6	45.2	69.0	46.1	68.8	46.4	68.0	47.6	67.1	48.8	83
84	71.2	44.5	70.5	45.8	69.8	46.7	69.6	47.0	68.8	48.2	68.0	49.4	84
85	72.1	45.0	71.3	46.3	70.7	47.2	70.5	47.5	69.6	48.8	68.8	50.0	85
86	72.9	45.6	72.1	46.8	71.5	47.8	71.3	48.1	70.5	49.3	69.6	50.5	86
87	73.8	46.1	73.0	47.3	72.3	48.3	72.1	48.6	71.3	49.9	70.4	51.1	87
88	74.7	46.6	73.8	47.9	73.2	48.9	72.9	49.2	72.1	50.5	71.2	51.7	88
89	75.5	47.2	74.7	48.5	74.0	49.4	73.8	49.8	72.9	51.0	72.0	52.3	89
90	76.3	47.7	75.5	49.0	74.8	50.0	74.6	50.3	73.7	51.6	72.8	52.9	90
91	77.2	48.2	76.3	49.6	75.7	50.6	75.4	50.9	74.5	52.2	73.6	53.5	91
92	78.0	48.7	77.2	50.1	76.5	51.1	76.3	51.4	75.4	52.8	74.4	54.1	92
93	78.9	49.3	78.0	50.6	77.3	51.7	77.1	52.0	76.2	53.3	75.2	54.7	93
94	79.7	49.8	78.9	51.2	78.2	52.2	77.9	52.6	77.0	53.9	76.0	55.2	94
95	80.6	50.3	79.7	51.7	79.0	52.8	78.8	53.1	77.8	54.5	76.9	55.8	95
96	81.4	50.9	80.5	52.3	79.8	53.3	79.6	53.7	78.6	55.1	77.7	56.4	96
97	82.3	51.4	81.4	52.8	80.6	53.9	80.4	54.2	79.5	55.6	78.5	57.0	97
98	83.1	51.9	82.2	53.4	81.5	54.4	81.2	54.8	80.3	56.2	79.3	57.6	98
99	84.0	52.3	83.1	53.9	82.3	55.0	82.1	55.4	81.1	56.8	80.1	58.2	99
100	84.8	53.0	83.9	54.5	83.0	55.5	82.9	55.9	81.9	57.4	80.9	58.8	100
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	58 Deg.		57 Deg.		5 Point.		56 Deg.		55 Deg.		54 Deg.		

Dist.	3¾ Point		37 Deg.		38 Deg.		39 Deg.		3½ Point.		40 Deg.		Dist.
	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	00.8	00.6	00.8	00.6	00.8	00.6	00.8	00.7	00.8	00.6	00.8	00.6	1
2	01.6	01.2	01.6	01.2	01.6	01.2	01.5	01.3	01.5	01.3	01.5	01.3	2
3	02.4	01.8	02.4	01.8	02.4	01.8	02.3	01.9	02.3	01.9	02.3	01.9	3
4	03.2	02.4	03.2	02.4	03.1	02.5	03.5	02.5	03.1	02.5	03.1	02.6	4
5	04.0	03.0	04.0	03.0	03.9	03.1	03.9	03.1	03 9	03.2	03.8	03.2	5
6	04.8	03.6	04.8	03.6	04.7	03.7	04.6	03.9	04.6	03.8	04.6	03.9	6
7	05.6	04.2	05.6	04.2	05.5	04.3	05.4	04.4	05.4	04.4	05.4	04.5	7
8	06.4	04.8	06.4	04.8	06.3	04.9	06.2	05.0	06.2	05.1	06.1	05.1	8
9	07.2	05.4	07.2	05.4	07.1	05.5	06.9	05.7	07.0	05.7	06.9	05.8	9
10	08.0	06.0	08.0	06.0	07.9	06.2	07.8	06.3	07.7	06.3	07.7	06.4	10
11	08.8	06.6	08.8	06.6	08.7	06.8	08.5	06.9	08.5	07.0	08.4	07.1	11
12	09.6	07.1	09.6	07.2	09.4	07.4	09.3	07.5	09.3	07.6	09.2	07.7	12
13	10.4	07.7	10.4	07.8	10.2	08.1	10.1	08.2	10.0	08.2	10.0	08.4	13
14	11.2	08.3	11.2	08.4	11.0	08.7	10.9	08.8	10.8	08.9	10.7	09.0	14
15	12.0	08 9	12.0	09 0	11.8	09.3	11.6	09.4	11.6	09.5	11.5	09.6	15
16	12.8	09 5	12.8	09.6	12.6	09.8	12.4	10.1	12.4	10.1	12.3	10.3	16
17	13.6	10.1	13.6	10.2	13.4	10.5	13.2	10.7	13.1	10.8	13.0	10.9	17
18	14.5	10.7	14.4	10.8	14.2	11.1	13.9	11.3	13.9	11.4	13.8	11.6	18
19	15.3	11.3	15.2	11.4	15.0	11.7	14.8	12.0	14.7	12.0	14.5	12.2	19
20	16.1	11.9	16.0	12.0	15.8	12.3	15.5	12.6	15.5	12.7	15.3	12.9	20
21	16.9	12.5	16.8	12.6	16.5	12.9	16.3	13.2	16.2	13.3	16.1	13.5	21
22	17.7	13.1	17.6	13.2	17.3	13.5	17.1	13.8	17.0	14.0	16.8	14.1	22
23	18.5	13.7	18.4	13.8	18.1	14.2	17.9	14.5	17.8	14.6	17.6	14.8	23
24	19.3	14.3	19.2	14.4	18.9	14.8	18.6	15.1	18.5	15.2	18.4	15.4	24
25	20.1	14.9	20.0	15.0	19.7	15.4	19.4	15.7	19.3	15.9	19.1	16.1	25
26	20.9	15.5	20.8	15.6	20.5	16.0	20.2	16.4	20.1	16.5	19.6	16.7	26
27	21.7	16.1	21.6	16.2	21.3	16.6	21.0	17.0	20.9	17 1	20.7	17.4	27
28	22.5	16.7	22.4	16.8	22.1	17.2	21.8	17.6	21.6	17.8	21.4	18.0	28
29	23.3	17.3	23.2	17.4	22.8	17.8	22.1	18.3	22.4	18.4	22.2	18.6	29
30	24.1	17.9	24.9	18.0	23.6	18.5	23.3	18.9	23.2	19.0	23.0	19.3	30
31	24.9	18.5	24.8	18.6	24.4	19.1	24.1	19.5	24.0	19.7	23.7	19.9	31
32	25.7	19.1	25.6	19.3	25.2	19.7	24.9	20.1	24.7	20.3	24.5	20.6	32
33	26.5	19.7	26.4	19 9	26.0	20.3	25.6	20.8	25.5	20.9	25.3	21.2	33
34	27.3	20.2	27.1	20.5	26.8	20.9	26.4	21.4	26.3	21.6	26.0	21 9	34
35	28.1	20.8	27 9	21.1	27.6	21.5	27.2	22.0	27.0	22.2	26.8	22.5	35
36	28 9	21.4	28.7	21.7	28.4	22.2	28.0	22.7	27.8	22.8	27.6	23.1	36
37	29.7	22.0	29.5	22.3	29.2	22.8	28.8	23.3	28.6	23.5	28.3	23.8	37
38	30.5	22.9	30.3	22.9	29.9	23.4	29.5	23.9	29.4	24.1	29.1	24.4	38
39	31.3	23.2	31.1	23.5	30.7	24.0	30.3	24.5	30.1	24.7	29.9	25.1	39
40	32.1	23.8	31.9	24.1	31.5	24.6	31.1	25.2	30.9	25.4	30.6	25.7	40
41	32.9	24.4	32.7	24.7	32.3	25.2	31.9	25.8	31.7	26.0	31.4	26.4	41
42	33.7	25.0	33.5	25.3	33.1	25.9	32.6	26.4	32 5	26.6	32.2	27.0	42
43	34.5	25.6	34.3	25.9	33.9	26.5	33.4	27.1	33.2	27.3	32.9	27.6	43
44	35.3	26.2	35.1	26.5	34.7	27 1	34.2	27.7	34.0	27.9	33.7	28 3	44
45	36.1	26.8	35.9	27.1	35.5	27.7	35.0	28.5	34.8	28.5	34 5	28 9	45
46	36 9	27.4	36.7	27.7	36.2	28.3	35.7	29.0	35.6	29.2	35.2	29.6	46
47	37.7	28.0	37.5	28.3	37.0	28.9	36.5	29 6	36.3	29.8	36.0	30.2	47
48	38.5	28.6	38.3	28.9	37.8	29.5	37.3	30.2	37.1	30 4	36.8	30.9	48
49	39.3	29 2	39.1	29.5	38.6	30.2	38.1	30.8	37.9	31.1	37.5	31.5	49
50	40.1	29 8	39.9	30.1	39.4	30.8	38.9	31.5	38.6	31.7	38.3	32.1	50
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Dist.	4¼ Point.		53 Deg.		52 Deg.		51 Deg.		4½ Point.		50 Deg.		Dist.

Dist.	3¼ Point.		37 Deg.		38 Deg.		39 Deg.		3½ Point.		40 Deg.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	41.0	30.4	40.7	30.7	40.2	31.4	39.6	32.1	39.4	32.3	39.1	32.8	51
52	41.8	31.0	41.5	31.3	41.0	32.0	40.4	32.7	40.2	33.0	39.8	33.4	52
53	42.6	31.6	42.3	31.9	41.8	32.6	41.2	33.3	41.0	33.6	40.6	34.1	53
54	43.4	32.2	43.1	32.5	42.5	33.2	42.0	34.0	41.7	34.3	41.4	34.7	54
55	44.2	32.8	43.9	33.1	43.3	33.9	42.7	34.6	42.5	34.9	42.1	35.4	55
56	45.0	33.3	44.7	33.7	44.1	34.5	43.5	35.2	43.3	35.5	42.9	36.0	56
57	45.8	33.9	45.5	34.3	44.9	35.1	44.3	35.9	44.1	36.2	43.7	36.6	57
58	46.6	34.5	46.3	34.9	45.7	35.8	45.1	36.5	44.8	36.8	44.4	37.3	58
59	47.4	35.1	47.1	35.5	46.5	36.3	45.8	37.1	45.6	37.4	45.2	37.9	59
60	48.2	35.7	47.9	36.1	47.3	36.9	46.6	37.8	46.4	38.1	46.0	38.6	60
61	49.0	36.3	48.7	36.7	48.1	37.5	47.4	38.4	47.1	38.7	46.7	39.3	61
62	49.8	36.9	49.5	37.3	48.9	38.2	48.2	39.0	47.9	39.3	47.5	39.9	62
63	50.6	37.5	50.3	37.9	49.6	38.8	49.0	39.6	48.7	40.0	48.3	40.5	63
64	51.4	38.1	51.1	38.5	50.4	39.4	49.7	40.3	49.5	40.6	49.0	41.2	64
65	52.2	38.7	51.9	39.1	51.2	40.0	50.5	40.9	50.2	41.2	49.8	41.8	65
66	53.0	39.3	52.7	39.7	52.0	40.6	51.3	41.5	51.0	41.9	50.5	42.4	66
67	53.8	39.9	53.5	40.3	52.8	41.2	52.1	42.2	51.8	42.5	51.3	43.1	67
68	54.6	40.5	54.3	40.9	53.6	41.9	52.8	42.8	52.6	43.1	52.1	43.7	68
69	55.4	41.1	55.1	41.5	54.4	42.5	53.6	43.4	53.3	43.8	52.9	44.4	69
70	56.2	41.7	55.9	42.1	55.2	43.1	54.4	44.0	54.1	44.4	53.6	45.0	70
71	57.0	42.3	56.7	42.7	55.9	43.7	55.2	44.7	54.9	45.0	54.4	45.6	71
72	57.8	42.9	57.5	43.3	56.7	44.3	55.9	45.3	55.7	45.7	55.1	46.3	72
73	58.6	43.5	58.3	43.9	57.5	44.9	56.7	45.9	56.4	46.3	55.9	46.9	73
74	59.4	44.1	59.1	44.5	58.3	45.6	57.5	46.6	57.2	46.9	56.7	47.6	74
75	60.2	44.7	59.9	45.1	59.1	46.2	58.3	47.2	58.0	47.6	57.4	48.2	75
76	61.0	45.3	60.7	45.7	60.0	46.8	59.1	47.8	58.7	48.2	58.2	48.9	76
77	61.8	45.9	61.5	46.3	60.7	47.4	59.8	48.5	59.5	48.8	59.0	49.5	77
78	62.7	46.5	62.3	46.9	61.5	48.0	60.6	49.1	60.3	49.5	59.7	50.1	78
79	63.5	47.1	63.1	47.5	62.2	48.6	61.4	49.7	61.1	50.1	60.5	50.8	79
80	64.3	47.7	63.9	48.1	63.0	49.3	62.2	50.3	61.8	50.7	61.3	51.4	80
81	65.1	48.3	64.7	48.7	63.8	49.9	62.9	51.0	62.6	51.4	62.0	52.1	81
82	65.9	48.8	65.5	49.3	64.6	50.5	63.7	51.6	63.4	52.0	62.8	52.7	82
83	66.7	49.4	66.3	49.9	65.4	51.1	64.5	52.2	64.2	52.6	63.6	53.4	83
84	67.5	50.0	67.1	50.5	66.2	51.7	65.3	52.9	64.9	53.3	64.3	54.0	84
85	68.3	50.6	67.9	51.1	67.0	52.3	66.1	53.5	65.7	53.9	65.1	54.6	85
86	69.1	51.2	68.7	51.7	67.8	52.9	66.8	54.1	66.5	54.6	65.9	55.3	86
87	69.9	51.8	69.5	52.4	68.6	53.6	67.6	54.8	67.2	55.2	66.6	55.9	87
88	70.7	52.4	70.3	53.0	69.3	54.2	68.4	55.4	68.0	55.8	67.4	56.6	88
89	71.5	53.0	71.1	53.6	70.1	54.8	69.2	56.0	68.8	56.5	68.2	57.2	89
90	72.3	53.6	71.9	54.2	70.9	55.4	69.9	56.6	69.6	57.1	68.9	57.8	90
91	73.1	54.2	72.7	54.8	71.7	56.0	70.7	57.3	70.3	57.7	69.7	58.5	91
92	73.9	54.8	73.5	55.4	72.5	56.6	71.5	57.9	71.1	58.4	70.5	59.1	92
93	74.7	55.4	74.3	56.0	73.3	57.3	72.3	58.5	71.9	59.0	71.2	59.8	93
94	75.5	56.0	75.1	56.6	74.1	57.9	73.0	59.2	72.7	59.6	72.0	60.4	94
95	76.3	56.6	75.9	57.2	74.9	58.5	73.8	59.8	73.4	60.3	72.8	61.1	95
96	77.1	57.2	76.7	57.8	75.6	59.1	74.6	60.4	74.2	60.9	73.5	61.7	96
97	77.9	57.8	77.5	58.4	76.4	59.7	75.4	61.0	75.0	61.5	74.3	62.1	97
98	78.7	58.4	78.3	59.0	77.2	60.3	76.2	61.7	75.7	62.2	75.0	63.0	98
99	79.5	59.0	79.1	59.6	78.0	60.9	76.9	62.3	76.5	62.8	75.8	63.6	99
100	80.3	59.6	79.9	60.2	78.8	61.6	77.7	62.9	77.3	63.4	76.6	64.3	100
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Dist.	4¾ Point.		53 Deg.		52 Deg.		51 Deg.		4½ Point.		50 Deg.		Dist.

Dist.	41 Deg.		42 Deg.		3¾ Point.		43 Deg		44 Deg.		4 Points.		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	00.7	00.7	00.7	00.7	00.7	00.7	00.7	00.7	00.7	00.7	00.7	00.7	1
2	01.5	01.3	01.5	01.3	01.5	01.3	01.5	01.4	01.4	01.4	01.4	01.4	2
3	02.3	02.0	02.2	02.0	02.2	02.0	02.2	02.0	02.2	02.1	02.1	02.1	3
4	03.0	02.6	03.0	02.7	03.0	02.7	02.9	02.7	02.9	02.8	02.8	02.8	4
5	03.8	03.3	03.7	03.3	03.7	03.4	03.6	03.4	03.6	03.5	03.5	03.5	5
6	04.5	03.9	04.5	04.0	04.4	04.0	04.4	04.1	04.3	04.2	04.2	04.2	6
7	05.3	04.0	05.2	04.7	05.2	04.7	05.1	04.8	05.0	04.9	04.9	04.9	7
8	06.0	05.2	05.9	05.3	05.9	05.4	05.8	05.5	05.7	05.6	05.7	05.7	8
9	06.8	05.9	06.7	06.0	06.7	06.0	06.7	06.1	06.5	06.2	06.4	06.4	9
10	07.5	06.6	07.4	06.7	07.4	06.7	07.3	06.8	07.2	06.9	07.1	07.1	10
11	08.3	07.2	08.2	07.4	08.1	07.4	08.0	07.5	07.9	07.6	07.8	07.8	11
12	09.1	07.9	08.9	08.0	08.9	08.1	08.8	08.2	08.6	08.3	08.5	08.5	12
13	09.8	08.5	09.7	08.7	09.6	08.7	09.5	08.9	09.3	09.0	09.2	09.2	13
14	10.6	09.2	10.4	09.4	10.4	09.4	10.2	09.5	10.1	09.7	09.9	09.9	14
15	11.3	09.8	11.1	10.0	11.1	10.1	11.0	10.2	10.8	10.4	10.6	10.6	15
16	12.1	10.5	11.9	10.7	11.9	10.7	11.7	10.9	11.5	11.1	11.3	11.3	16
17	12.8	11.1	12.6	11.4	12.6	11.4	12.4	11.6	12.2	11.8	12.0	12.0	17
18	13.6	11.8	13.4	12.0	13.3	12.1	13.2	12.3	12.9	12.5	12.7	12.7	18
19	14.3	12.5	14.1	12.7	14.1	12.8	13.9	13.0	13.7	13.2	13.4	13.4	19
20	15.1	13.1	14.9	13.4	14.8	13.4	14.6	13.6	14.4	13.9	14.1	14.1	20
21	15.8	13.8	15.6	14.0	15.6	14.1	15.4	14.3	15.1	14.6	14.8	14.8	21
22	16.6	14.4	16.3	14.7	16.3	14.8	16.1	15.0	15.8	15.3	15.5	15.5	22
23	17.4	15.1	17.1	15.4	17.0	15.4	16.8	15.7	16.5	16.0	10.3	16.3	23
24	18.1	15.7	17.8	16.1	17.8	16.1	17.5	16.4	17.3	16.7	17.0	17.0	24
25	18.9	16.4	18.6	16.7	18.5	16.8	18.3	17.1	18.0	17.4	17.7	17.7	25
26	19.6	17.1	19.3	17.5	19.3	17.4	19.0	17.7	18.7	18.1	18.4	18.4	26
27	20.4	17.7	20.1	18.1	20.0	18.1	19.7	18.4	19.4	18.8	19.1	19.1	27
28	21.1	18.4	20.8	18.7	20.7	18.8	20.5	19.1	20.1	19.4	19.8	19.8	28
29	21.9	19.0	21.5	19.4	21.5	19.5	21.2	19.8	20.9	20.1	20.5	20.5	29
30	22.0	19.7	22.3	20.1	22.2	20.1	21.9	20.5	21.6	20.8	21.2	21.2	30
31	23.4	20.3	23.0	20.7	23.0	20.8	22.6	21.1	22.3	21.5	21.9	21.9	31
32	24.1	21.0	23.8	21.4	23.7	21.5	23.4	21.8	23.0	22.2	22.6	22.6	32
33	24.9	21.6	24.5	22.1	24.4	22.2	24.1	22.5	23.7	22.9	23.3	23.3	33
34	25.0	22.3	25.3	22.7	25.2	22.8	24.9	23.2	24.5	23.6	24.0	24.0	34
35	26.4	23.0	26.0	23.4	25.9	23.5	25.6	23.9	25.2	24.3	24.7	24.7	35
36	27.2	23.6	26.7	24.1	26.7	24.2	26.3	24.5	25.9	25.0	25.4	25.4	36
37	27.9	24.3	27.5	24.7	27.4	24.8	27.0	25.2	26.6	25.7	26.1	26.1	37
38	28.7	24.9	28.2	25.4	28.2	25.5	27.3	25.9	27.3	26.4	26.9	26.9	38
39	29.4	25.6	29.0	26.1	28.9	26.2	28.5	26.6	28.0	27.1	27.6	27.6	39
40	30.2	26.2	29.7	26.8	29.6	26.9	29.2	27.3	28.8	27.8	28.3	28.3	40
41	31.0	26.9	30.5	27.4	30.4	27.5	30.0	28.0	29.5	28.5	29.0	29.0	41
42	31.7	27.5	31.2	28.1	31.1	28.2	30.7	28.6	30.2	29.2	29.7	29.7	42
43	32.5	28.2	31.9	28.8	31.9	28.9	31.4	29.3	30.9	29.9	30.4	30.4	43
44	33.2	28.9	32.7	29.4	32.6	29.6	32.2	30.0	31.6	30.6	31.1	31.1	44
45	34.0	29.5	33.4	30.1	33.3	30.2	32.9	30.7	32.4	31.3	31.8	31.8	45
46	34.7	30.2	34.2	30.8	34.1	30.9	33.6	31.4	33.1	32.0	32.5	32.5	46
47	35.5	30.8	34.9	31.4	34.8	31.6	34.4	32.1	33.8	32.6	33.2	33.2	47
48	36.3	31.5	35.7	32.1	35.6	32.2	35.1	32.7	34.5	33.3	33.9	33.9	48
49	37.0	32.1	36.4	32.8	36.3	32.9	35.8	33.4	35.2	34.0	34.6	34.6	49
50	37.7	32.8	37.2	33.5	37.0	33.6	36.6	34.1	36.0	34.7	35.3	35.3	50
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Dist.	49 Deg.		48 Deg.		4¼ Point.		47 Deg.		46 Deg.		4 Points.		Dist.

Dist.	41 Deg. Lat.	41 Deg. Dep.	42 Deg. Lat.	42 Deg. Dep.	3¾ Point Lat.	3¾ Point Dep.	43 Deg. Lat.	43 Deg. Dep.	44 Deg. Lat.	44 Deg. Dep.	4 Point Lat.	4 Point Dep.	Dist.
51	38.5	33.5	37.9	34.1	37.8	34.2	37.3	34.8	36.7	35.4	36.1	36.1	51
52	39.2	34.1	38.6	34.8	38.5	34.9	38.0	35.5	37.4	36.1	36.8	36.8	52
53	40.0	34.8	39.4	35.5	39.3	35.6	38.8	36.1	38.1	36.8	37.5	37.5	53
54	40.8	35.4	40.1	36.1	40.0	36.3	39.5	36.8	38.8	37.5	38.2	38.2	54
55	41.5	36.0	40.9	36.8	40.7	36.9	40.2	37.5	39.6	38.2	38.9	38.9	55
56	42.3	36.7	41.6	37.5	41.5	37.6	41.0	38.2	40.3	38.9	39.6	39.6	56
57	43.0	37.4	42.4	38.1	42.2	38.3	41.7	38.9	41.0	39.6	40.3	40.3	57
58	43.8	38.1	43.1	38.8	43.0	38.9	42.4	39.5	41.7	40.3	41.0	41.0	58
59	44.5	38.7	43.8	39.5	43.7	39.6	43.1	40.2	42.4	41.0	41.7	41.7	59
60	45.3	39.4	44.6	40.1	44.5	40.3	43.8	40.9	43.2	41.7	42.4	42.4	60
61	46.0	40.0	45.3	40.8	45.2	41.0	44.6	41.7	43.9	42.4	43.1	43.1	61
62	46.8	40.7	46.1	41.5	45.9	41.6	45.3	42.3	44.6	43.1	43.8	43.8	62
63	47.6	41.3	46.8	42.2	46.7	42.3	46.1	43.0	45.3	43.8	44.5	44.5	63
64	48.3	42.0	47.5	42.8	47.4	43.0	46.8	43.6	46.0	44.5	45.3	45.3	64
65	49.1	42.6	48.3	43.5	48.2	43.6	47.5	44.3	46.8	45.1	46.0	46.0	65
66	49.8	43.3	49.0	44.2	48.9	44.3	48.3	45.0	47.5	45.8	46.7	46.7	66
67	50.6	44.0	49.8	44.8	49.6	45.0	49.0	45.7	48.2	46.5	47.4	47.4	67
68	51.3	44.6	50.5	45.5	50.4	45.7	49.7	46.4	48.9	47.2	48.1	48.1	68
69	52.1	45.3	51.3	46.2	51.1	46.3	50.5	47.1	49.6	47.9	48.8	48.8	69
70	52.8	45.9	52.0	46.8	51.9	47.0	51.2	47.7	50.3	48.6	49.5	49.5	70
71	53.6	46.6	52.8	47.5	52.6	47.7	51.9	48.4	51.1	49.3	50.2	50.2	71
72	54.3	47.2	53.5	48.2	53.3	48.3	52.7	49.1	51.8	50.0	50.9	50.9	72
73	55.1	47.9	54.2	48.8	54.1	49.0	53.4	49.8	52.5	50.7	51.6	51.6	73
74	55.9	48.5	55.0	49.5	54.8	49.7	54.1	50.5	53.2	51.4	52.3	52.3	74
75	56.8	49.2	55.7	50.2	55.6	50.4	54.8	51.1	53.9	52.1	53.0	53.0	75
76	57.4	49.9	56.5	50.9	56.3	51.0	55.6	51.8	54.7	52.8	53.7	53.7	76
77	58.1	50.5	57.2	51.5	57.1	51.7	56.3	52.5	55.4	53.5	54.4	54.4	77
78	58.9	51.2	58.0	52.1	57.8	52.4	57.0	53.2	56.1	54.2	55.2	55.1	78
79	59.6	51.8	58.7	52.8	58.5	53.0	57.8	53.9	56.8	54.9	55.9	55.9	79
80	60.4	52.5	59.4	53.5	59.3	53.7	58.5	54.6	57.5	55.6	56.6	56.6	80
81	61.1	53.1	60.2	54.2	60.0	54.4	59.2	55.2	58.3	56.3	57.3	57.3	81
82	61.9	53.8	60.9	54.9	60.8	55.1	60.0	55.9	59.0	57.0	58.0	58.0	82
83	62.6	54.5	61.7	55.5	61.5	55.7	60.7	56.6	59.7	57.6	58.7	58.7	83
84	63.4	55.1	62.4	56.2	62.2	56.4	61.4	57.3	60.4	58.3	59.4	59.4	84
85	64.2	55.9	63.2	56.9	63.0	57.1	62.2	58.0	61.1	59.0	60.1	60.1	85
86	64.9	56.4	63.9	57.5	63.7	57.7	63.0	58.6	61.9	59.7	60.8	60.8	86
87	65.7	57.1	64.7	58.2	64.5	58.4	63.6	59.3	62.6	60.4	61.5	61.5	87
88	66.4	57.7	65.4	58.9	65.2	59.1	64.4	60.0	63.3	61.1	62.2	62.2	88
89	67.2	58.4	66.1	59.6	65.9	59.8	65.1	60.7	64.0	61.8	62.9	62.9	89
90	67.9	59.1	66.9	60.2	66.7	60.4	65.8	61.4	64.7	62.5	63.6	63.6	90
91	68.7	59.7	67.6	60.9	67.4	61.1	66.5	62.1	65.5	63.2	64.3	64.3	91
92	69.4	60.4	68.4	61.6	68.2	61.8	67.3	62.7	66.2	63.9	65.0	65.0	92
93	70.2	61.0	69.1	62.2	68.9	62.4	68.0	63.4	66.9	64.6	65.8	65.8	93
94	71.0	61.7	69.9	62.9	69.6	63.1	68.7	64.1	67.6	65.3	66.5	66.5	94
95	71.7	62.3	70.6	63.6	70.4	63.8	69.5	64.8	68.3	66.0	67.2	67.2	95
96	72.5	63.0	71.3	64.2	71.1	64.5	70.2	65.5	69.1	66.7	67.9	67.9	96
97	73.2	63.6	72.1	64.9	71.9	65.1	70.9	66.1	69.8	67.4	68.6	68.6	97
98	74.0	64.3	72.8	65.6	72.6	65.8	71.7	66.8	70.5	68.1	69.3	69.9	98
99	74.7	65.0	73.6	66.2	73.4	66.5	72.4	67.5	71.2	68.8	70.0	70.0	99
100	75.5	65.6	74.3	66.9	74.1	67.2	73.1	68.2	71.9	69.5	70.7	70.7	100
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dist.
	49 Deg.		48 Deg.		4¼ Point.		47 Deg.		46 Deg.		4 Points.		

T

To
M
C
c

A

TABLE

OF

Meridional Parts,

To every Degree and Minute of the MERIDIAN, for performing the ſeveral Caſes in NAVIGATION, according to *Mercator*, or Mr. *Wright*'s Projection.

M.	0 d	1 d	2 d	3 d	4 d	5 d	6 d	7 d	8 d	9 d	10 d	M.
0	0	60	120	180	240	300	361	421	481	542	603	0
1	1	61	121	181	241	301	362	422	482	543	604	1
2	2	62	122	182	242	302	363	423	483	544	605	2
3	3	63	123	183	243	303	364	424	484	545	606	3
4	4	64	124	184	244	304	365	425	485	546	607	4
5	5	65	125	185	245	305	366	426	486	547	608	5
6	6	66	126	186	246	306	367	427	488	548	609	6
7	7	67	127	187	247	307	368	428	489	549	610	7
8	8	68	128	188	248	308	369	429	490	550	611	8
9	9	69	129	189	249	309	370	430	491	551	612	9
10	10	70	130	190	250	310	371	431	492	552	613	10
11	11	71	131	191	251	311	372	432	493	553	614	11
12	12	72	132	192	252	312	373	433	494	554	615	12
13	13	73	133	193	253	313	374	434	495	555	616	13
14	14	74	134	194	254	314	375	435	496	556	617	14
15	15	75	135	195	255	315	376	436	497	557	618	15
16	16	76	136	196	256	316	377	437	498	558	619	16
17	17	77	137	197	257	317	378	438	499	559	620	17
18	18	78	138	198	258	318	379	439	500	560	621	18
19	19	79	139	199	259	319	380	440	501	561	622	19
20	20	80	140	200	260	320	381	441	502	562	623	20
21	21	81	141	201	261	321	382	442	503	563	624	21
22	22	82	142	202	262	322	383	443	504	564	625	22
23	23	83	143	203	263	323	384	444	505	565	626	23
24	24	84	144	204	264	324	385	445	506	566	627	24
25	25	85	145	205	265	325	386	446	507	567	628	25
26	26	86	146	206	266	326	387	447	508	568	629	26
27	27	87	147	207	267	327	388	448	509	569	630	27
28	28	88	148	208	268	328	389	449	510	570	631	28
29	29	89	149	209	269	329	390	450	511	571	632	29
30	30	90	150	210	270	330	391	451	512	573	633	30
31	31	91	151	211	271	331	392	452	513	574	634	31
32	32	92	152	212	272	332	393	453	514	575	635	32
33	33	93	153	213	273	333	394	454	515	576	636	33
34	34	94	154	214	274	334	395	455	516	577	638	34
35	35	95	155	215	275	335	396	456	517	578	639	35
36	36	96	156	216	276	336	397	457	518	579	640	36
37	37	97	157	217	277	337	398	458	519	580	641	37
38	38	98	158	218	278	338	399	459	520	581	642	38
39	39	99	159	219	279	339	400	460	521	582	643	39
40	40	100	160	220	280	340	401	461	522	583	644	40
41	41	101	161	221	281	341	402	462	523	584	645	41
42	42	102	162	222	282	342	403	463	524	585	646	42
43	43	103	163	223	283	343	404	464	525	586	647	43
44	44	104	164	224	284	344	405	465	526	587	648	44
45	45	105	165	225	285	345	406	466	527	588	649	45
46	46	106	166	226	286	346	407	467	528	589	650	46
47	47	107	167	227	287	347	408	468	529	590	651	47
48	48	108	168	228	288	348	409	469	530	591	652	48
49	49	109	169	229	289	349	410	470	531	592	653	49
50	50	110	170	230	290	350	411	471	532	593	654	50
51	51	111	171	231	291	351	412	472	533	594	655	51
52	52	112	172	232	292	352	413	473	534	595	656	52
53	53	113	173	233	293	353	414	474	535	596	657	53
54	54	114	174	234	294	354	415	475	536	597	658	54
55	55	115	175	235	295	355	416	476	537	598	659	55
56	56	116	176	236	296	356	417	477	538	599	660	56
57	57	117	177	237	297	357	418	478	539	600	661	57
58	58	118	178	238	298	358	419	479	540	601	662	58
59	59	119	179	239	299	359	420	480	541	602	663	59

M.	11 d	12 d	13 d	14 d	15 d	16 d	17 d	18 d	19 d	20 d	21 d	M.
0	664	725	787	848	910	973	1035	1098	1161	1225	1289	0
1	665	726	788	849	911	974	36	99	62	26	90	1
2	666	727	789	850	912	975	37	1100	63	27	91	2
3	667	728	790	851	913	976	38	01	65	28	92	3
4	668	729	791	852	914	977	39	02	66	29	93	4
5	669	730	792	854	916	978	40	03	67	30	94	5
6	670	731	793	855	917	979	41	04	68	31	96	6
7	671	732	794	856	918	980	42	05	69	32	97	7
8	672	733	795	857	919	981	44	07	70	34	98	8
9	673	734	796	858	920	982	45	08	71	35	99	9
10	674	735	797	859	921	983	1046	1109	1172	1236	1300	10
11	675	737	798	860	922	984	47	10	73	37	01	11
12	676	737	799	861	923	985	48	11	74	38	02	12
13	677	738	800	862	924	986	49	12	75	39	03	13
14	678	740	801	863	925	987	50	13	76	40	04	14
15	679	741	802	864	926	988	51	14	77	41	05	15
16	680	742	803	865	927	989	52	15	78	42	06	16
17	681	743	804	866	928	990	53	16	79	43	07	17
18	682	744	805	867	929	991	54	17	80	44	08	18
19	683	745	806	868	930	992	55	18	81	45	09	19
20	684	746	807	869	931	993	1056	1119	1183	1246	1311	20
21	685	747	808	870	932	994	57	20	84	47	12	21
22	686	748	809	871	933	996	58	21	85	48	13	22
23	687	749	810	872	934	997	59	22	86	50	14	23
24	688	750	811	873	935	998	60	23	87	51	15	24
25	689	751	812	874	936	999	61	24	88	52	16	25
26	690	752	813	875	937	1000	62	25	89	53	17	26
27	691	753	814	876	938	1001	63	27	90	54	18	27
28	692	754	815	877	939	1002	64	28	91	55	19	28
29	694	755	816	878	940	1003	66	29	92	56	20	29
30	695	756	817	879	941	1004	1067	1130	1193	1257	1321	30
31	696	757	819	880	942	05	68	31	94	58	22	31
32	697	758	820	881	944	06	69	32	95	59	23	32
33	698	759	821	882	945	07	70	33	96	60	25	33
34	699	760	822	883	946	08	71	34	97	61	26	34
35	700	761	823	884	947	09	72	35	98	62	27	35
36	701	762	824	886	948	10	73	36	1200	63	28	36
37	702	763	825	887	949	11	74	37	01	64	29	37
38	703	764	826	888	950	12	75	38	02	66	30	38
39	704	765	827	889	951	13	76	39	03	67	31	39
40	705	766	828	890	952	1014	1077	1140	1204	1268	1332	40
41	706	767	829	891	953	15	78	41	05	69	33	41
42	707	768	830	892	954	16	79	42	06	70	34	42
43	708	769	831	893	955	17	80	43	07	71	35	43
44	709	770	832	894	956	18	81	44	08	72	36	44
45	710	771	833	895	957	20	82	46	09	73	37	45
46	711	772	834	896	958	21	83	47	10	74	38	46
47	712	773	835	897	959	22	84	48	11	75	40	47
48	713	774	836	898	960	23	85	49	12	76	41	48
49	714	775	837	899	961	24	87	50	13	77	42	49
50	715	776	838	900	962	1025	1088	1151	1214	1278	1343	50
51	716	777	839	901	963	26	89	52	15	79	44	51
52	717	778	840	902	964	27	90	53	16	81	45	52
53	718	779	841	903	965	28	91	54	18	82	46	53
54	719	781	842	904	966	29	92	55	19	83	47	54
55	720	782	843	905	967	30	93	56	20	84	48	55
56	721	783	844	906	968	31	94	57	21	85	49	56
57	722	784	845	907	969	32	95	58	22	86	50	57
58	723	785	846	908	970	33	96	59	23	87	51	58
59	724	786	847	909	971	34	97	60	24	88	52	59

M.	22 d	23 d	24 d	25 d	26 d	27 d	28 d	29 d	30 d	31 d	32 d	M.
0	1354	1419	1484	1550	1616	1683	1751	1819	1888	1958	2228	0
1	55	20	85	51	17	85	52	20	89	59	29	1
2	56	21	86	52	19	86	53	22	91	60	31	2
3	57	22	87	53	20	87	54	23	92	61	32	3
4	58	23	88	54	21	88	56	24	93	63	33	4
5	59	24	89	55	22	89	57	25	94	64	34	5
6	60	25	91	57	23	90	58	26	95	65	35	6
7	61	26	92	58	24	91	59	27	96	66	37	7
8	62	27	93	59	25	93	60	28	98	67	38	8
9	63	28	94	60	26	94	61	30	99	68	39	9
10	1364	1429	1495	1561	1628	1695	1762	1831	1900	1970	2340	10
11	65	30	96	62	29	96	64	32	01	71	41	11
12	67	31	97	63	30	97	65	33	02	72	42	12
13	68	33	98	64	31	98	66	34	03	73	44	13
14	69	34	99	65	32	99	67	35	04	74	45	14
15	70	35	1500	66	33	1700	68	37	06	75	46	15
16	71	36	01	68	34	01	69	38	07	77	47	16
17	72	37	03	69	35	03	70	39	08	78	48	17
18	73	38	04	70	36	04	71	40	09	79	50	18
19	74	39	05	71	38	05	73	41	10	80	51	19
20	1375	1440	1506	1572	1639	1706	1774	1842	1911	1981	2352	20
21	76	41	07	73	40	07	75	43	13	82	53	21
22	77	42	08	74	41	08	76	45	14	84	54	22
23	78	44	09	75	42	09	77	46	15	85	55	23
24	79	45	10	76	43	10	78	47	16	86	57	24
25	80	46	11	78	44	12	79	48	17	87	58	25
26	82	47	12	79	45	13	81	49	18	88	59	26
27	83	48	14	80	46	14	82	50	20	89	60	27
28	84	49	15	81	48	15	83	51	21	91	61	28
29	85	50	16	82	49	16	84	53	22	92	63	29
30	1386	1451	1517	1583	1650	1717	1785	1854	1923	1993	2364	30
31	87	52	18	84	51	18	86	55	24	94	65	31
32	88	53	19	85	52	19	87	56	25	95	66	32
33	89	54	20	86	53	21	89	57	26	97	67	33
34	90	56	21	87	54	22	90	58	28	98	69	34
35	91	57	22	89	55	23	91	59	29	99	70	35
36	92	58	23	90	57	24	92	61	30	2000	71	36
37	94	59	25	91	58	25	93	62	31	01	72	37
38	95	60	26	92	59	26	94	63	32	02	73	38
39	96	61	27	93	60	27	95	64	33	04	74	39
40	1397	1462	1528	1594	1661	1728	1797	1865	1935	2005	2376	40
41	98	63	29	95	62	30	98	66	36	06	77	41
42	99	64	30	96	63	31	99	68	37	07	78	42
43	1400	65	31	97	64	32	1800	69	38	08	79	43
44	01	66	32	99	65	33	01	70	39	09	80	44
45	02	68	33	1600	67	34	02	71	40	11	82	45
46	03	69	34	01	68	35	03	72	42	12	83	46
47	04	70	36	02	69	36	04	73	43	13	84	47
48	05	71	37	03	70	37	06	74	44	14	85	48
49	07	72	38	04	71	39	07	76	45	15	86	49
50	1408	1473	1539	1605	1672	1740	1808	1877	1946	2017	2388	50
51	09	74	40	06	73	41	09	78	47	18	89	51
52	10	75	41	07	74	42	10	79	49	19	90	52
53	11	76	42	09	76	43	11	80	50	20	91	53
54	12	77	43	10	77	44	12	81	51	21	92	54
55	13	78	44	11	78	45	14	83	52	22	93	55
56	14	80	45	12	79	47	15	84	53	24	95	56
57	15	81	47	13	80	48	16	85	54	25	96	57
58	16	82	48	14	81	49	17	86	56	26	97	58
59	17	83	49	15	82	50	18	87	57	27	98	59

M.	33 d	34 d	35 d	36 d	37 d	38 d	39 d	40 d	41 d	42 d	43 d	M.
0	2099	2171	2244	2318	2393	2468	2545	2623	2702	2782	2863	0
1	2101	73	45	19	94	69	46	24	03	83	64	1
2	02	74	47	20	95	71	47	25	04	84	66	2
3	03	75	48	22	96	72	49	27	06	86	67	3
4	04	76	49	23	98	73	50	28	07	87	69	4
5	05	77	50	24	99	75	51	29	08	88	70	5
6	07	79	52	27	2400	76	53	30	10	90	71	6
7	08	80	53	26	01	77	54	32	11	91	73	7
8	09	81	54	28	03	78	55	33	12	92	74	8
9	10	82	55	29	04	80	56	34	14	94	75	9
10	2111	2183	2256	2330	2405	2481	2558	2636	2715	2795	2877	10
11	13	85	58	32	06	82	59	37	16	97	78	11
12	14	86	59	33	08	83	60	38	17	98	80	12
13	15	87	60	34	09	85	62	40	19	99	81	13
14	16	88	61	35	10	86	63	41	20	2801	82	14
15	17	90	63	36	11	87	64	42	21	02	84	15
16	19	91	64	38	13	89	66	44	23	03	85	16
17	20	92	65	39	14	90	67	45	24	05	86	17
18	21	93	66	40	15	91	68	46	25	06	88	18
19	22	94	67	41	16	92	69	48	27	07	89	19
20	2123	2196	2269	2343	2418	2494	2571	2649	2728	2809	2890	20
21	25	97	70	44	19	95	73	50	29	10	92	21
22	26	98	71	45	20	96	74	51	31	11	93	22
23	27	95	72	46	21	97	75	53	32	13	95	23
24	28	2200	74	48	23	99	76	54	33	14	96	24
25	29	02	75	49	24	2500	77	55	35	15	97	25
26	31	03	76	50	25	01	78	57	36	17	99	26
27	32	04	77	51	26	03	80	58	37	18	2900	27
28	33	05	78	53	28	04	81	59	39	20	02	28
29	34	06	80	54	29	05	82	61	40	21	03	29
30	2135	2208	2281	2355	2430	2506	2584	2662	2741	2822	2904	30
31	37	09	82	56	32	08	85	63	43	24	06	31
32	38	10	83	58	33	09	86	65	44	25	07	32
33	39	11	85	59	34	10	88	66	45	26	08	33
34	40	13	86	60	35	12	89	67	47	28	10	34
35	41	14	87	61	37	13	90	69	48	29	11	35
36	43	15	88	63	38	14	91	70	49	30	13	36
37	44	16	90	64	39	15	93	71	51	32	14	37
38	45	17	91	65	40	17	94	73	52	33	15	38
39	46	19	92	66	42	18	95	74	54	34	17	39
40	2147	2220	2293	2368	2443	2519	2597	2675	2755	2836	2918	40
41	49	21	94	69	44	20	98	76	56	37	19	41
42	50	22	96	70	45	22	99	78	58	39	21	42
43	51	23	97	71	47	23	2601	79	59	40	22	43
44	52	25	98	73	48	24	02	80	60	41	24	44
45	53	26	99	74	49	26	03	82	61	43	25	45
46	55	27	2301	75	50	27	04	83	63	44	26	46
47	56	28	02	76	52	28	06	84	64	45	28	47
48	57	30	03	78	53	29	07	86	66	47	29	48
49	58	31	04	79	54	31	08	87	67	48	31	49
50	2159	2232	2306	2380	2456	2532	2610	2688	2768	2849	2932	50
51	61	33	07	81	57	33	11	90	70	51	33	51
52	62	34	08	83	58	35	12	91	71	52	35	52
53	63	36	09	84	59	36	14	92	72	54	36	53
54	64	37	11	85	61	37	15	94	74	55	37	54
55	65	38	12	86	62	38	16	95	75	56	39	55
56	67	39	13	88	63	40	17	96	76	58	40	56
57	68	41	14	89	64	41	19	98	78	59	42	57
58	69	42	15	90	66	42	20	99	79	60	43	58
59	70	43	17	91	67	44	21	2700	80	62	44	59

M.	44 d	45 d	46 d	47 d	48 d	49 d	50 d	51 d	52 d	53 d	54 d	M.
0	2946	3030	3116	3203	3292	3382	3475	3569	3665	3765	3865	0
1	47	31	17	04	93	84	76	70	67	67	66	1
2	49	33	18	05	95	85	78	72	69	69	68	2
3	50	34	20	07	96	88	79	74	70	70	70	3
4	51	36	21	09	98	89	81	75	72	72	72	4
5	52	37	23	10	99	90	82	77	73	73	73	5
6	53	38	24	12	3301	91	84	78	75	75	75	6
7	54	40	26	13	02	93	85	80	77	77	77	7
8	55	41	27	14	04	94	87	82	78	78	78	8
9	56	42	29	16	05	96	89	83	80	79	80	9
10	2960	3044	3130	3217	3307	3397	3490	3585	3682	3780	3882	10
11	61	46	31	19	08	99	92	86	83	82	83	11
12	63	47	33	20	10	3400	93	88	85	84	85	12
13	64	48	34	22	12	02	95	90	87	85	87	13
14	65	50	36	23	13	03	96	91	88	87	89	14
15	67	51	37	25	14	05	98	93	90	89	90	15
16	68	53	39	26	16	07	99	94	91	91	92	16
17	69	54	40	28	17	08	3501	96	93	92	94	17
18	71	55	42	29	19	19	03	98	95	94	95	18
19	72	57	43	31	20	11	04	99	96	96	97	19
20	2974	3058	3144	3232	3322	3413	3506	3600	3698	3797	3899	20
21	75	60	46	33	23	14	07	02	3700	99	3901	21
22	76	61	47	34	25	16	09	04	01	3801	02	22
23	78	63	49	36	26	17	10	06	03	02	04	23
24	79	64	50	38	28	19	12	07	05	04	06	24
25	81	65	52	40	29	20	14	09	06	06	07	25
26	82	67	53	41	31	22	15	10	08	07	09	26
27	83	68	55	42	32	23	17	12	09	09	11	27
28	85	70	56	44	34	25	18	14	10	11	13	28
29	86	71	57	45	35	27	20	15	13	12	14	29
30	2988	3073	3159	3247	3337	3428	3521	3617	3714	3814	3916	30
31	89	74	60	48	38	30	23	18	16	16	18	31
32	90	75	62	50	40	31	25	20	18	17	20	32
33	92	77	63	51	41	33	26	22	19	19	21	33
34	93	78	65	53	43	34	28	23	21	21	23	34
35	95	80	66	54	44	36	29	25	23	22	25	35
36	96	81	68	56	46	37	31	26	24	24	26	36
37	98	83	69	57	47	39	32	28	26	26	28	37
38	99	84	71	59	49	40	34	30	28	27	30	38
39	3000	85	72	60	50	42	36	31	29	29	32	39
40	3002	3087	3173	2362	3352	3443	3537	3633	3731	3831	3933	40
41	03	88	75	63	53	45	39	35	32	33	35	41
42	05	90	76	65	55	47	40	36	34	34	37	42
43	06	91	78	66	56	48	42	38	36	36	39	43
44	07	93	79	68	58	49	43	39	37	38	40	44
45	09	94	81	69	59	51	45	41	39	39	42	45
46	10	95	82	71	61	53	47	43	41	41	44	46
47	12	97	84	72	62	54	48	44	42	43	45	47
48	13	98	85	74	64	56	50	46	44	44	47	48
49	14	3100	87	75	65	57	51	48	46	46	49	49
50	3016	3101	3188	3277	3367	3459	3553	3649	3747	3848	3951	50
51	17	03	90	78	68	61	55	51	49	49	52	51
52	19	04	91	80	70	62	56	52	51	51	54	52
53	20	05	92	81	71	64	58	54	52	53	56	53
54	22	07	94	83	73	65	59	56	54	55	58	54
55	23	08	95	84	74	67	61	57	56	56	59	55
56	24	10	97	86	76	68	62	59	57	58	61	56
57	26	11	98	87	78	70	64	60	59	60	63	57
58	27	13	3200	89	79	71	66	62	61	61	65	58
59	29	14	01	90	81	73	67	64	62	63	66	59

M.	55 d	56 d	57 d	58 d	59 d	60 d	61 d	62 d	63 d	64 d	65 d	M.
0	3968	4074	4183	4294	4409	4528	4649	4775	4805	5040	5179	0
1	70	76	85	96	11	30	52	77	07	42	82	1
2	72	78	88	98	13	32	54	80	10	44	84	2
3	73	79	89	4300	15	34	56	82	12	47	86	3
4	75	81	90	02	17	36	58	84	14	49	89	4
5	77	83	92	04	19	38	60	86	16	51	91	5
6	79	85	94	06	21	40	62	88	19	53	93	6
7	80	87	96	08	23	42	64	90	21	56	96	7
8	82	88	97	10	25	44	66	92	23	58	98	8
9	84	90	99	12	27	46	68	95	25	60	5201	9
10	3986	4092	4201	4313	4429	4548	4670	4797	4927	5063	5203	10
11	87	94	03	15	31	50	72	99	30	65	05	11
12	89	97	05	17	33	52	74	4801	32	67	08	12
13	91	99	07	19	35	54	76	03	34	70	10	13
14	93	4100	09	21	37	56	78	05	36	72	12	14
15	94	01	10	23	39	58	81	07	38	74	15	15
16	96	03	12	25	41	60	83	10	41	76	17	16
17	98	05	14	27	43	62	85	12	43	79	20	17
18	4000	06	16	29	44	64	87	14	45	81	22	18
19	01	08	18	31	46	66	89	16	47	83	24	19
20	4003	4110	4220	4332	4448	4568	4691	4818	4950	5086	5227	20
21	05	12	22	34	50	70	93	20	52	88	29	21
22	07	14	23	36	52	72	55	22	54	90	32	22
23	08	15	25	38	54	74	97	25	56	93	34	23
24	10	17	27	40	56	76	99	27	59	95	36	24
25	12	19	29	42	58	78	4701	29	61	97	39	25
26	14	21	31	44	60	80	04	31	63	5100	41	26
27	15	23	33	46	62	82	06	33	65	02	44	27
28	17	24	35	48	64	84	08	35	67	04	46	28
29	19	26	36	50	66	86	10	38	70	07	48	29
30	4021	4128	4238	4352	4468	4588	4712	4840	4972	5109	5251	30
31	22	30	40	53	70	90	14	42	74	11	53	31
32	24	32	42	55	72	92	16	44	76	14	56	32
33	28	33	44	57	74	94	18	46	79	16	58	33
34	29	35	46	59	76	96	20	48	81	18	61	34
35	30	37	48	61	78	98	22	50	83	20	63	35
36	31	39	49	63	80	4600	24	53	85	23	65	36
37	33	41	51	65	82	02	27	55	88	25	68	37
38	35	43	53	66	84	04	29	57	90	27	70	38
39	37	44	55	67	4488	06	31	59	92	30	73	39
40	4038	4146	4257	4371	4489	4608	4733	4861	4994	5132	5275	40
41	40	48	59	73	90	10	35	64	97	35	78	41
42	42	50	61	75	92	13	37	66	99	37	80	42
43	44	52	63	77	94	15	39	68	5001	39	83	43
44	46	54	64	78	96	17	41	70	03	42	85	44
45	47	55	66	80	98	19	43	72	06	44	87	45
46	49	57	68	82	4500	21	46	75	08	46	90	46
47	51	59	70	84	02	23	48	77	10	49	92	47
48	53	61	72	86	04	25	50	80	12	51	95	48
49	54	63	74	88	06	27	52	81	15	53	97	49
50	4056	4164	4276	4390	4508	4629	4754	4883	5017	5156	5299	50
51	58	66	78	92	10	31	56	85	20	58	5302	51
52	60	68	79	94	12	33	58	88	22	60	04	52
53	62	70	81	96	14	35	60	90	24	63	07	53
54	63	72	82	98	16	37	63	92	26	65	09	54
55	65	74	83	4400	18	38	65	94	28	68	12	55
56	67	75	85	02	20	41	67	96	31	70	14	56
57	69	77	89	04	22	43	69	99	33	72	17	57
58	70	79	91	05	24	45	71	4901	35	74	19	58
59	72	81	93	07	26	47	73	03	38	77	21	59

M.	66 d	67 d	68 d	69 d	70 d	71 d	72 d	73 d	74 d	75 d	76 d	M.
0	5324	5474	5261	5795	5967	6149	6336	6538	6747	6971	7215	0
1	26	78	34	98	70	50	39	39	50	75	10	1
2	29	80	37	5801	72	53	42	42	54	79	24	2
3	31	82	39	04	75	56	45	46	58	83	28	3
4	34	85	42	06	78	59	50	49	61	87	32	4
5	36	87	45	09	81	62	52	52	65	91	36	5
6	39	90	47	12	84	65	55	56	69	95	40	6
7	41	95	50	15	87	68	58	59	72	99	45	7
8	44	98	53	18	90	71	62	63	76	7003	49	8
9	46	99	57	20	93	74	66	66	78	06	53	9
10	5349	5500	5658	5823	5996	6177	6368	6570	6783	7010	7255	10
11	51	03	61	26	99	80	71	73	87	14	57	11
12	54	05	64	29	6002	83	75	77	91	18	61	12
13	56	08	66	32	05	87	78	80	94	22	65	13
14	59	11	69	34	08	90	81	84	98	26	70	14
15	61	13	72	37	11	93	85	87	6802	30	74	15
16	64	16	74	40	14	96	88	90	05	34	78	16
17	66	18	77	43	17	99	91	94	09	38	82	17
18	68	21	80	46	20	6202	94	97	13	42	87	18
19	71	23	82	49	23	05	98	6601	16	46	91	19
20	5373	5526	5685	5851	6026	6208	6401	6605	6820	7050	7295	20
21	76	29	88	54	29	12	04	08	24	54	99	21
22	78	31	91	57	32	15	08	11	27	58	7303	22
23	81	34	93	60	34	18	11	15	31	61	08	23
24	83	37	96	63	38	21	14	18	35	65	12	24
25	86	39	99	66	40	24	18	22	39	69	16	25
26	88	42	5701	68	43	27	21	25	42	73	21	26
27	91	44	04	71	46	30	24	29	46	77	25	27
28	93	47	07	74	49	34	27	32	50	81	29	28
29	96	49	10	77	52	37	31	36	54	85	33	29
30	5398	5552	5712	5880	6055	6240	6434	6639	6857	7089	7338	30
31	5401	55	15	83	58	43	37	43	61	93	42	31
32	03	57	18	86	61	46	41	47	65	97	46	32
33	06	60	20	88	64	49	44	51	69	7101	50	33
34	09	63	23	91	67	52	47	54	72	05	55	34
35	11	65	26	94	70	56	51	57	76	09	59	35
36	14	68	29	97	73	59	54	61	80	13	63	36
37	16	70	32	5900	76	62	57	64	84	17	68	37
38	19	73	34	03	79	65	61	68	87	21	72	38
39	21	76	37	06	82	68	64	71	90	26	76	39
40	5424	5578	5740	5909	6085	6271	6468	6675	6895	7130	7381	40
41	26	81	42	11	89	75	71	78	99	34	85	41
42	29	84	45	14	92	78	74	82	6903	38	89	42
43	31	86	48	17	95	81	78	86	06	42	94	43
44	34	89	51	20	98	84	81	89	10	46	98	44
45	36	92	54	23	6101	87	84	93	14	50	7403	45
46	39	94	56	26	04	91	88	96	18	54	07	46
47	41	97	59	29	07	94	91	6700	22	58	11	47
48	44	99	62	32	10	97	94	03	25	62	16	48
49	46	5602	65	35	13	6300	98	07	29	66	20	49
50	5449	5605	5767	5937	6116	6303	6501	6711	6933	7170	7424	50
51	52	07	70	40	20	07	05	14	37	74	29	51
52	54	10	73	43	22	10	08	18	41	78	33	52
53	58	13	76	46	25	13	11	21	44	82	39	53
54	59	15	78	49	28	16	15	25	48	87	42	54
55	62	18	81	52	31	19	18	29	52	91	46	55
56	64	21	84	55	34	23	22	32	56	95	51	56
57	67	23	87	58	37	26	25	36	60	99	55	57
58	69	26	90	61	40	29	28	39	64	7203	59	58
59	72	29	92	64	43	32	32	43	68	07	64	59

M.	77 d	78 d	79 d	80 d	81 d	82 d	83 d	84 d	85 d	M.
0	7469	7746	8047	8377	8741	9148	9609	10148	10770	0
1	73	51	53	83	48	55	17	150	781	1
2	78	56	58	85	54	63	25	160	793	2
3	82	61	63	95	61	70	34	170	804	3
4	86	65	69	8400	67	77	42	179	816	4
5	91	70	74	06	74	84	50	189	827	5
6	95	75	79	12	80	92	59	199	839	6
7	7500	80	84	18	87	99	67	209	851	7
8	04	85	90	24	93	9206	75	218	863	8
9	09	90	95	30	99	14	84	228	875	9
10	7513	7795	8100	8435	8806	9221	9692	10238	10886	10
11	18	99	06	41	13	28	9701	248	899	11
12	22	7804	11	47	19	36	09	258	910	12
13	27	09	16	53	26	43	18	268	922	13
14	31	14	22	59	32	50	26	278	934	14
15	36	19	27	65	39	58	35	288	946	15
16	40	24	32	71	45	65	43	298	958	16
17	45	29	38	77	52	73	52	308	971	17
18	50	34	43	83	59	80	60	318	983	18
19	54	39	49	89	65	88	69	328	995	19
20	7559	7844	8154	8494	8872	9295	9777	10338	11007	20
21	63	49	59	8500	78	9303	86	348	020	21
22	68	54	65	06	85	10	95	358	032	22
23	72	59	70	12	92	18	9803	368	047	23
24	77	64	76	18	98	25	12	378	058	24
25	82	69	81	24	8905	33	31	389	072	25
26	86	75	87	30	12	40	36	399	082	26
27	91	79	92	36	19	48	38	410	095	27
28	95	84	98	42	25	56	47	420	107	28
29	7600	89	8203	49	32	63	56	430	120	29
30	7605	7894	8208	8555	8939	9371	9865	10441	11133	30
31	09	99	14	61	46	79	74	451	146	31
32	14	7904	19	67	52	86	82	462	158	32
33	19	09	25	73	59	94	91	472	171	33
34	23	14	31	79	66	9402	9900	483	184	34
35	28	19	36	85	73	10	09	494	197	35
36	32	24	42	91	80	17	18	504	210	36
37	37	29	47	97	87	25	27	515	223	37
38	42	34	53	8603	93	33	36	526	236	38
39	46	39	58	10	9000	41	45	536	258	39
40	7651	7944	8264	8616	9007	9449	9954	10547	11263	40
41	56	49	69	22	14	56	63	558	276	41
42	61	54	75	28	21	64	73	569	289	42
43	65	59	80	34	28	72	82	579	303	43
44	70	65	86	41	35	80	92	590	316	44
45	75	70	92	47	42	88	10000	601	330	45
46	79	75	97	53	49	96	009	612	343	46
47	84	80	8303	59	56	9504	018	623	357	47
48	89	85	09	65	63	12	028	634	371	48
49	94	90	15	72	70	20	037	645	384	49
50	7698	7995	8320	8678	9077	9528	10046	10656	11398	50
51	7703	8001	26	84	84	36	056	668	412	51
52	08	05	31	91	91	44	065	679	426	52
53	13	11	37	97	98	52	074	690	440	53
54	17	16	43	8703	9105	60	084	701	454	54
55	22	21	49	10	12	68	093	711	468	55
56	27	27	54	16	20	76	103	724	482	56
57	32	32	60	22	27	85	112	735	496	57
58	37	37	66	29	34	93	122	747	510	58
59	41	42	71	35	41	9601	131	758	525	59

M.	86 d	87 d	88 d	89 d	M.
0	11539	12521	13920	16317	0
1	553	540	949	376	1
2	568	559	978	435	2
3	582	579	14007	495	3
4	597	598	037	557	4
5	611	618	067	619	5
6	626	638	097	683	6
7	641	658	127	748	7
8	656	671	158	814	8
9	671	698	189	881	9
10	11686	12718	14220	16950	10
11	701	738	252	020	11
12	716	759	284	092	12
13	731	779	316	165	13
14	746	800	348	240	14
15	761	821	381	310	15
16	777	842	414	394	16
17	792	863	448	474	17
18	808	984	481	556	18
19	823	906	515	640	19
20	11839	12027	14550	17726	20
21	855	949	584	814	21
22	870	970	619	904	22
23	886	929	655	997	23
24	902	13014	691	18090	24
25	918	037	727	191	25
26	934	029	764	292	26
27	950	081	800	396	27
28	967	104	838	503	28
29	983	127	876	615	29
30	11999	13150	14914	18729	30
31	12016	172	952	848	31
32	032	196	992	971	32
33	049	219	15031	19098	33
34	066	243	071	230	34
35	086	267	111	368	35
36	099	294	152	511	36
37	116	315	194	660	37
38	133	339	236	817	38
39	150	363	278	980	39
40	12167	13388	15321	20152	40
41	185	413	365	333	41
42	202	437	409	524	42
43	220	463	453	726	43
44	237	488	499	941	44
45	255	513	545	21170	45
46	273	539	591	416	46
47	290	565	638	680	47
48	308	591	686	697	48
49	326	617	734	22279	49
50	12344	13643	15183	22623	50
51	363	670	833	23005	51
52	381	697	884	23434	52
53	399	724	935	23926	53
54	408	751	987	24499	54
55	426	779	16040	25786	55
56	445	807	094	26046	56
57	464	834	148	27192	57
58	483	863	204	28911	58
59	502	891	260	32348	59

Navigation New Modelled;

OR,

The WHOLE ART Performed

BY A

NEW METHOD:

TEACHING

The Young Mariner all the Sea-Terms, with a Deſcription of a Ship compleatly Rigged, her Ropes ſeverally deſcribed; with all uſeful Tables neceſſary in the Art of NAVIGATION.

This New Method is performed without Tables or Inſtruments, teaching how to keep a Reckoning both in Latitude and Longitude:

ILLUSTRATED WITH

Practical EXAMPLES of keeping a Journal, and correcting it by an Obſervation; with a new Way of finding the VARIATION, and Time of HIGH-WATER, at any known Port.

LIKEWISE

A new and correct Method for finding the Longitude in any Place of the World, any Day at Noon when the Sun can be ſeen, without any Regard to or Dependance upon the Dead-Reckoning, as alſo Current-Sailing.

By HENRY WILSON.

DUBLIN:

Printed by BOULTER GRIERSON, Printer to the King's Moſt Excellent Majeſty, M,DCCLXVII.

A Ship describ'd and Sea-Terms explain'd.

I Shall here give you the draught of a ſhip, with her rigging, that ſo you may not altogether be a ſtranger to the names of the maſts and tackle at your firſt going aboard a ſhip; and then ſhall give you the explanation of the moſt uſeful ſea-terms.

1. The enſign.
2. The mizen-vane.
3. The mizen-top-ſail.
4. The mizen-top-ſail-yard.
5. The croſs-jack-yard.
6. The mizen-yard.
7. The main-vane.
8. The main-pendant.
9. The main-top-gallant-ſail.
10. The main-top-ſail.
11. The main-ſail.
12. The fore-vane.
13. The fore-top-gallant-ſail.
14. The fore-top-ſail.
15. The fore-ſail.
16. The jack.
17. The ſprit-ſail-top-ſail.
18. The ſprit-ſail.
19. The fore-top-gallant-ſtay.
20. The fore-top-gallant-bow-lines.
21. The fore-top-maſt-ſtay.
22. The fore-top-ſail-bow-lines.
23. The crane-line.
24. The fore-ſtay.
25. The main-ſtay.
26. The main-top-maſt-ſtay.
27. The main-top-gallant-ſtay.
28. The main-top-gallant-bow-lines.
29. The fore-top-gallant-braces.
30. The fore-top-ſail-braces.
31. The main-top-ſail-bow-line.
32. The galleries.
33. The poop-lanthorns.
34 The main-top-ſail-brace.

a. The mizen-maſt.
b. The main-maſt.
c. The fore-maſt.
d. The bow-ſprit.

Mizen-top-maſt and running Rigging.

a. The mizen-top-maſt.
b. The mizen-top-ſail-brace.
c. The mizen-top-ſail-clew-line.
d. The mizen-top-ſail-ſheet.
e. The mizen-top-ſail-lifts.
f. The mizen-crow-foot.
g. Hoiſting-line for a penant.
h. The mizen-ſheet.

Mizen-maſt.

a. The main-top-gallant-maſt.
b. The main-top-gallant-lifts.
c. The main-top-gallant-yard.
d. The main-top-gallant-braces.
e. The main-top-maſt.
f. The main-top-maſt-back-ſtay.
g. The main-top-ſail-lifts.
h. The main-top-ſail-braces.
k. The main-top-ſail-clew-lines.
l. The main-top-ſail-leech-lines.

 n. The

n. The main-top-sail-bunt-lines
m. The main-lifts.
o. The main-yard.
r. The main-braces.
s. The main-sheet.
t. The main-tacks.
v. The main-shrowds.

Fore-mast.

a. The fore-top-gallant-mast.
b. The fore-top-gallant-lifts.
c. The fore-top-gallant-yard.
d. The fore-top-gallant-braces.
e. The fore-top-mast.
f. The-fore-top-mast-back-stay.
g. The fore-top-sail-lifts.
h. The fore-top-sail-braces.
k. The fore-top-sail-clew-lines.
l. The fore-top-sail-leech-lines.
n. The fore-top-sail-bunt-lines.
m. The fore-lifts.
o. The fore-yard.
p. The fore-leech-lines.
q. The fore-bunt-lines.
r. The fore-braces.
s. The fore-sheets.
t. The fore-tacks.
v. The fore-shrowds.
x. The fore-clew-garnet.

The bow-sprit.

a. The sprit-sail-top-mast.
b. The sprit-sail-top-sail-lifts.
c. The sprit-top-sail-yard.
d. The sprit - sail-top - mast - shrowds.
e. The sprit-sail-top-sail-braces.
f. The sprit-sail-top-sail-crow-foot.
g. The sprit-sail-top-sail-sheets.
h. The horse on the bow-sprit.
l. Standing - lifts for sprit-sail-yard.
m. The sprit-sail-yard.
n. The sprit-sail-sheets.
o. The sprit-sail-clew-lines.
r. The crane-line.

An explanation of the most useful sea terms.

A.

AFT or *abaft*, fromward the fore part of the ship, or toward the stern, as the *mast hangs aft*, that is, towards the stern.

How chear ye fore and aft? that's how fares all your ship's company?

Amain, a word used by a man of war to his enemy, and signifies *yield*.

Strike amain, that is, lower your top-sails.

The anchor is a peek, that signifies the anchor is right under the hawse or hole, through which the cable belonging to the anchor runs out.

The anchor is a cock-bell, that is, hangs up and down by the ship's side.

The anchor is foul, that is, the cable is about the fluke.

An awning, a sail or the like, supported like a canopy over the deck, to prevent the scorching heat of the sun in hot climates.

B.

To bale, to lade the water out of the ship's hold with buckets, or the like.

Trench the ballaſt, divide or ſeparate it.

The ballaſt ſhoots, that is, runs over from one ſide to another.

To bare with the land, &c. to ſail towards it.

To bare in, that is, to ſail before or with a wind into a harbour or channel.

A piece of ordnance does come to bear, that is, lies right with the mark.

Bear up, a term uſed in conding the ſhip, when they would have her ſail more before the wind.

Bear up round, put her right before the wind.

To belaye, to make faſt any running rope.

To bend a cable, is to make it faſt to the anchor.

A birth, a convenient ſpace to moor a ſhip in.

A bight, any part of the rope between the end.

The bilge, the breadth of the place the ſhip reſts on when ſhe is a-ground.

The ſhip is bilged, that is, ſhe ſtruck off ſome of her timber on a rock or anchor, and ſprings a leak.

A bittical or *binnacle*, that whereon the compaſs ſtands.

A bitter, a turn of a cable about the bits.

The bites, two main ſquare pieces of timber, to which the cables are faſtned when the ſhip rides at anchor.

A bonnet, an addition to another ſail; when they faſten it on, they ſay, *lace on the bonnet*; and when they take it off, *ſhake off the bonnet*; it is very rarely faſtned to any other, than the mizen, main, fore-ſail, and ſprit-ſail; and thoſe ſails are called courſes, as main-courſe and bonnet, not main-ſail and bonnet.

A boom, a long pole uſed to ſpread out the clue of the ſtudding-ſail, &c.

Board and board, a term uſed when two ſhips come ſo near as to touch one another.

To go a board, to go into a ſhip.

To make a board, or *board it up*, is to turn to windward.

To break bulk, to open the hold, and take out goods thence.

C

Careening, is bringing a ſhip to lie down on one ſide, while they trim and caulk the other.

Caulking, is driving of ockham, ſpan hair, and the like, into all the ſeams of the ſhip, to keep out water.

To chaſe, is to purſue another ſhip, and the ſhip ſo purſued is called the *chaſe*.

To cond, or *cun*, is to direct or guide, and to *cun a ſhip*, is to direct a perſon at the helm how to ſteer her. If the ſhip go *before the wind*, then he who cuns the ſhip uſes theſe terms to him at the helm, *ſtarboard*, *port*, *helm a midſhips*, ſtarboard,

is to put the helm to the starboard or right side, to make the ship go to the larboard or left; for the ship always sails contrary to the helm. In keeping the ship *near the wind*, these terms are used, *loof, keep your loof. Fall not off, veer no more, keep her to, touch the wind, have a care of the lee-latch.* To make her go *more large*, they say, *ease the helm, no near, bear up.* To keep her upon the *same point, sailing large*, they use, *steddy*, but upon a wind, *thus, thus, as you go*, and the like. *The ship goes lasking, quartering, veering* or *large*, are terms of the same signification, *viz.* that she neither goes by a wind nor before a wind, but betwixt both.

The course, is that point of the compass on which the ship sails; also the sails are called courses.

Cut the sail, that is, unfurl it, and let it fall down. *A sail is well cut*, that is well fashioned.

D

Dead-water, the eddy-water at the stern of the ship.

To disembogue, is to go out of the mouth or straits of a gulph.

To dispart, is to find out the difference of diameters of metals betwixt the breech and mouth of a piece of ordnance.

The deck is flush fore and aft, that is, is laid from stem to stern without any falls or risings.

E

End for end, a term used when a rope runs all out of the block, so that it is unreeved; as when a cable or hawser runs all out at the hawse, we say, *the cable at the hawse is run out end for end.*

F

A fathom, a measure containing six feet.

A fack, is one circle of any rope quoil'd cable or up round.

To farthel or furl a sail, is to wrapt it up close together, and bind it with little strings called *gaskets* fast to the yard.

To fish a mast or yard, is to fasten a piece of timber or plank to the mast or yard to strengthen it, which plank is called a *fish*.

To lower or strike the flag, is to pull it down upon the cap, and in fight it is a token of yielding; but otherwise of great respect.

To heave out the flag, is to warp it about the staff.

Free the boat or ship, is to bale or pump the water out.

G

The ship's gage, is so many foot as she sinks in the water; (or to speak now like a seaman) so many foot of water as she draws.

Weather-gage, is when one ship has the wind, or is to the weather of another.

A loom gale, a little wind.

One

One ship gales away from another, is fair weather, when there is but little wind, that ship which hath most wind, and sails fastest, is said to *gale* away from the other.

To grave a ship, is to bring her to lie dry a ground, to burn off her old filth.

The ship gripes, that is, turns her head to the wind more than she should.

H

To hale, is the same to pull.

To over hale, is when a rope is haled too stiff, to hale it the contrary way, thereby to make it more slack.

To hale a ship, is to call her company to know whether they are bound, &c. and is done after this manner, *hoa the ship!* or only *hoa!* to which they answer *hae*. Also to salute another ship with trumpets or the like, is called *hailing*.

Fresh the hause, a term used when that part of the cable that lies in the hawse is fretted or chafed, and they would have more cable veered out, that another part of it may rest in the hawse. When two cables that come through two several hawses are twisted, the untwisting them is called *clearing the hawse*. *Thwart the hawse, and ride upon the hawse*, are terms used when a ship lies thwart or cross, or with her stern before another ship's hawse. *Note*, That the hawses are the great holes at the head of the ship, through which the cables run when she lies at anchor.

The ship heels, that is, inclines more to one side than another, as *she heels to starboard*, that is, turns up her larboard-side, to lye down on the starboard.

To hitch, is to catch hold, or make fast.

The hold of a ship, is that part betwixt the keelson and the lower deck, where all goods, stores, and victuals do lye. *Rummage the hold*, is used for removing or clearing the goods and things in the *hold*. *Stowing the hold*, is when they take goods into the *hold*.

To hoise, is to hale or lift up, as *hoise the water in, hoise up the yards.*

Hulling, when a ship is at sea, and takes in all her sails she is said to *hull*.

L

The ship labours, that is rools and tumbles much.

Land-fall, is a term when we expect to see land; as we had a good *land-fall*, that is made the land, according to our reckoning.

Landlocked, is when the land lies round about us, so that no point is open to the sea.

Land-to, a ſhip is ſaid to *land-to*, when ſhe is at ſo great a diſtance as only juſt to diſcern the land.

To laſh, is to bind, as *laſh the fiſh on the maſt*, that is bind it to the maſt.

Launch, is to put out, as to *launch a ſhip*, is to put her forth off the dock into the water, but it is ſometimes likewiſe uſed in a negative ſenſe, as when a yard is hoiſted high enough uſually called aloud, *launch-hoe*, that is hoiſt no more.

To lay the land, is to loſe ſight of it.

The lee-ſhore, is that ſhore againſt which the wind blows.

Have a care of the lee-latch, that is, take heed the ſhip go not too much to the lee-ward.

A ſhip lies by the lee, that is, all her ſails lyeth flat againſt the maſts and ſhrouds.

M

Mizen-ſail, hath ſeveral words peculiar to it, as *ſet the mizen*, that is fit the mizen-ſail; *change the mizen*, that is, bring the yard to the other ſide of the maſt; *ſpeck the mizen*, that is, put the yard right up and down by the maſt; *ſpell the mizen*; that is let go the ſheet, and peek it up.

To moor a ſhip, is to lay out her anchors in ſuch a manner as it is moſt convenient for her to ride by ſafely.

N

Neap-tides, are the tides when the moon is in the ſecond and laſt quarter, and they are neither ſo high nor ſo low, nor ſo ſwift as the ſpring tides.

A ſhip is beneaped, a term uſed when the water does not flow high enough to bring a ſhip from off the ground, or out of a dock over a bar.

O

The offing, that is, fromward the ſhore, or out into the ſea; as *the ſhip ſtands for the offing*, that is, ſails from the ſhore into the ſea. When a ſhip keeps the middle of the channel, and comes not near the ſhoar, ſhe is ſaid to keep in the *offing*.

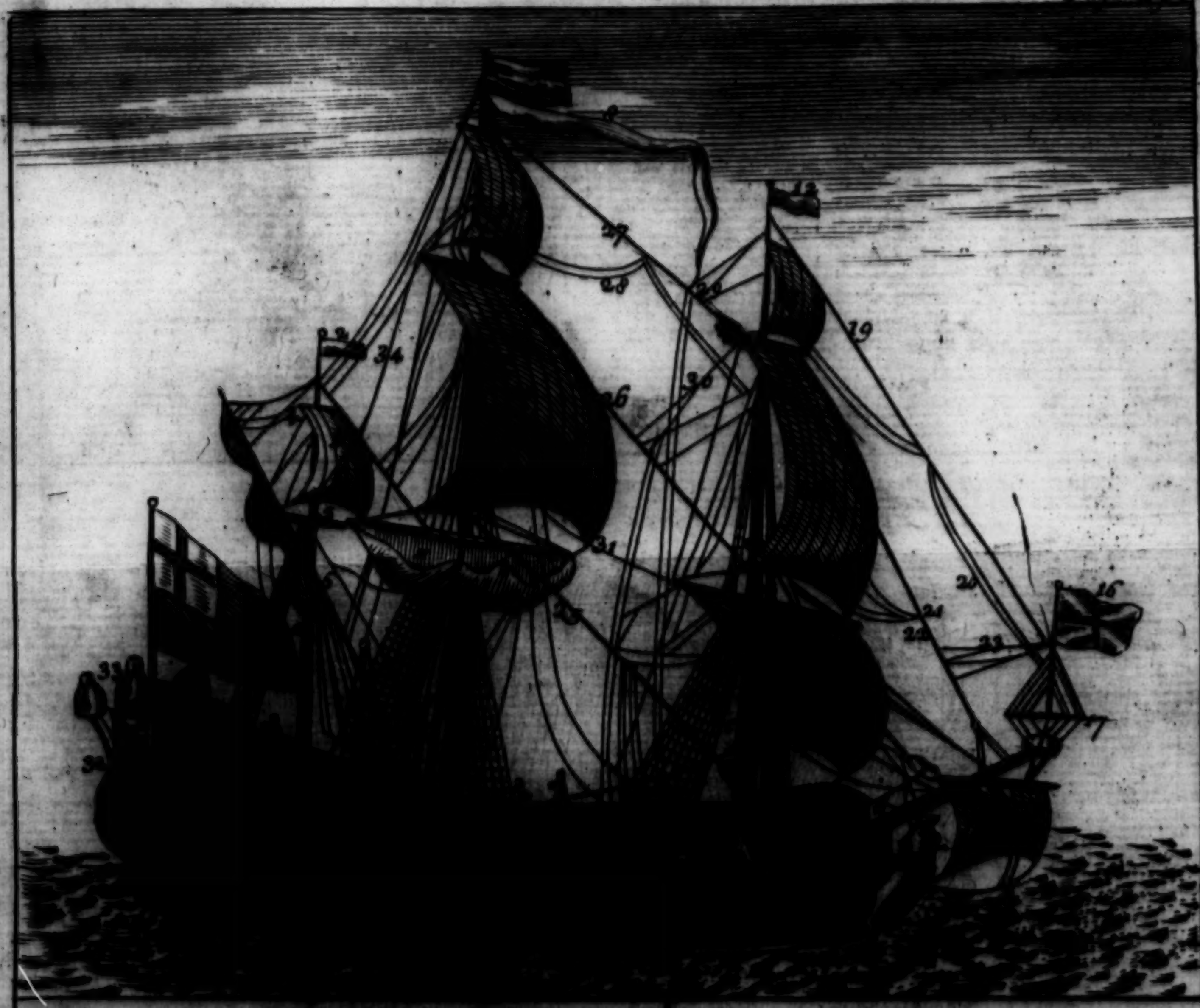
Offward, is contrary to the ſhore; as the ſtern of a ſhip lies to the off-ward, and her head to the ſhore-ward, that is, her ſtern lies toward the ſea, and her head to the ſhore.

Overſet, is turning over, but if a ſhip turn over on a ſide, when ſhe is trimming a-ground, it is called *overthrown*.

P

To parcel a ſeam, is (after the ſeam is caulked) to lay over it a narrow piece of canvaſs, and pour thereon hot pitch or tar.

To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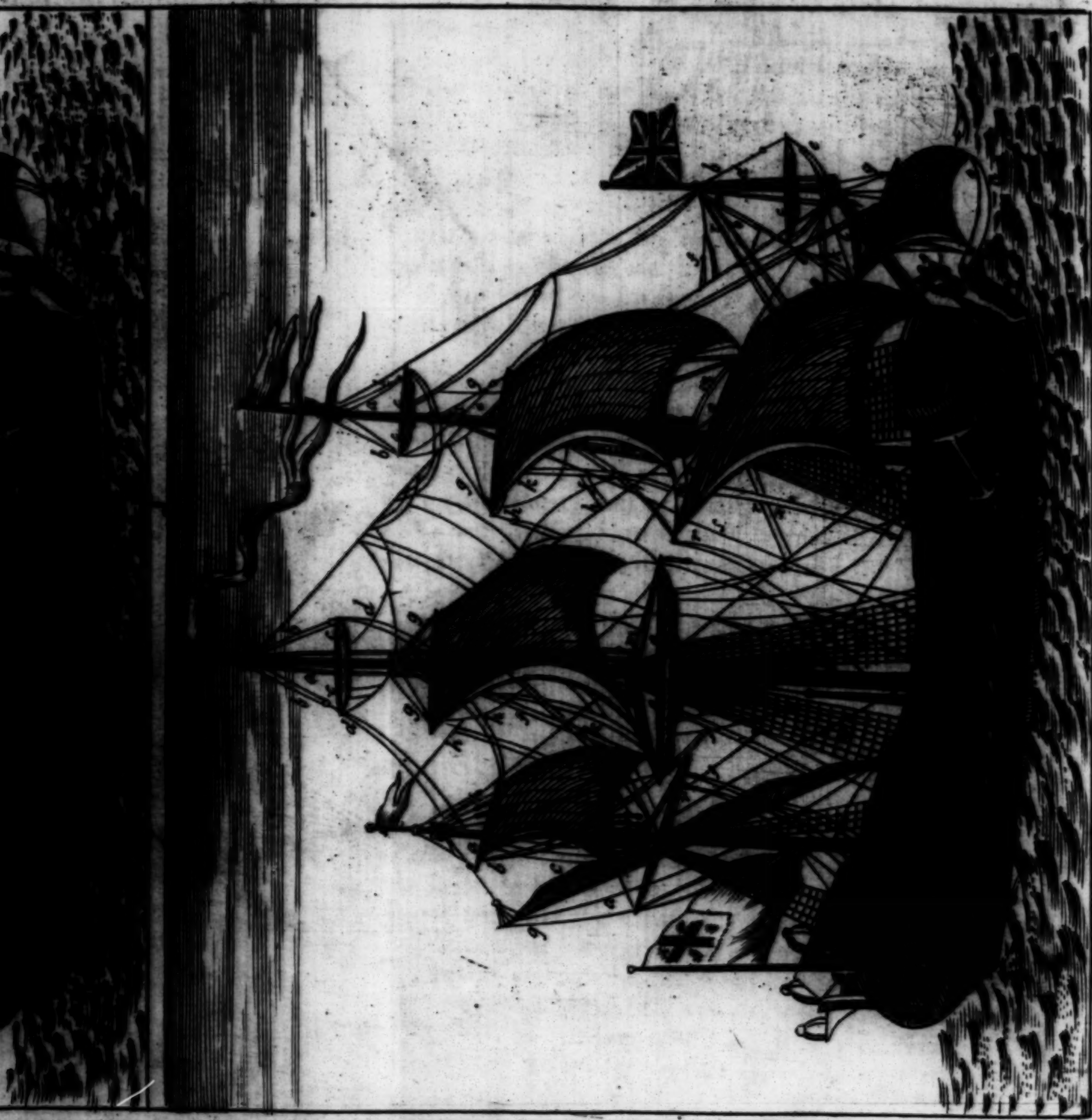

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Th

To pay a ſeam, is to lay hot pitch and tar on (after caulking) without canvaſs.

To ride a peek, is when the yards are ſo ordered, that they ſeem to make the figure of St, Andrew's croſs.

To purchaſe, in a ſhip bears the ſame ſenſe as *draw* many times, as the *capſtain purchaſes apace*, that is, draws in the cable apace.

Q

Quarter winds, are when the wind comes in abaft, the main ſhrouds even with the quarter.

A quoil, is a rope or cable laid up round one fack above another, and the laying the fack, is called *quoiling*.

R

A reach, is the diſtance between any two points of land, that lie in a right-line one from another.

To reeve, is to put a rope through a block; and to pull a rope out of a block is called *unreeving the rope*.

To ride, when a ſhip's anchor holds her faſt, ſo that ſhe does not drive with wind or tide, ſhe is ſaid to *ride at anchor*.

To ride athwart, is to ride with the ſhip's ſide to the tide.

To ride betwixt wind and tide, is when the wind and tide are contrary, and have equal ſtrength.

To ride hawſe-fall, is when in a rough ſea the water breaks into hawſes

A road, is any place near the land where ſhips may ride at anchor, and a ſhip riding there is called a *rooder*.

Rowſe-in, (that is, hale in) proper only to the cable or hawſer, and is uſed when the cable or hawſer is ſlack, to make it tight or ſtrait.

S

A ſail, beſides its proper ſignification (as belonging to the ſeveral yards, from which it takes its various names, as mainſail, &c.) it ſignifies alſo a ſhip, as when at ſea we deſcry a ſhip, we cry out *a ſail, a ſail*; likewiſe, if we ſpeak of a fleet or a number of ſhips together; we ſay the fleet conſiſted of 40 or 50 ſail, and not 40 or 50 ſhips.

To ſarve a rope, is to wind ſomething about it to keep it from jetting out.

To ſeaze, is to make faſt or bind.

The *ſhip ſeels*, that is when on a ſudden ſhe lies down on her ſide, and tumbles from one ſide to the other.

The *ſhip ſends*, that is, her head or ſtern falls deep in the trough or hallow of the ſea.

To *ſettle a deck*, is to lay it lower.

The *ſhip is ſewed*, that is goes in and out, not right forward.

To

To *found*, is to try with a line or other thing how deep the water is.

The *ship hath spent her masts*, that is her masts have been broke by foul weather; but if a ship lose her mast in fight, we say, *her masts were shot by the board.*

To *splice ropes*, is to untwist two ends of ropes, and then twist them both together, and fasten them by putting the parts of each rope through the other.

The *sail is split*, that is blown to pieces.

The *ship spooms*, that is, goes right before the wind without any sails.

Spring tides, are the tides at new and full moon, which flow highest and ebb lowest, and run strongest.

The *bowsprit steeves*, that is stands too upright. *Steeving* is likewise used by merchants when they stow cotton or wool, which being forced in with screws, they call *steeving* their cotton or wool.

Tack about, that is, bring the ship's head about to lie the other way.

Talle aft the sheets, a term used for hailing aft the sheets of the main or fore-sail.

A windward tide, when the tide runs against wind.

A leeward tide, when the wind and tide go both one way.

A tide gate, where the tide runs strong.

To *tide it up*, is to go with the tide against the wind, and when the tide alters, to lie at anchor till it serve again.

It flows tide and half tide, that is, it will be high-water sooner by three hours at the shore than in the offing.

To *tow*, is to drag any thing after the ship.

To *traverse*, is the ship's way.

V

To *veer*, is to let out; as *veer more rope, veer more sheet.*

W.

The ship is walt, that is wants ballast.

To *weather a ship*, is to go to windward of her.

To *wind a ship*, is to bring her head about.

How winds the ship? that is, upon what point of the compass does she lie with her head?

To *would*, is to bind ropes about the mast or the like, to keep on a fish to strengthen it.

Y

The *ship ywas*, that is, goes in and out, and does not steer steddy.

How

How to work a ship at sea, and to manage her in fight.

S. SInce you design to shew me the practical part of Navigation, I wonder you have not taught me yet how to work a ship at sea?

T. Although I have not done it, it is not that I have forgot how necessary it is to a beginner, but only because captain Sturmy hath treated of it, so full and well in that useful book of his, the Mariner's Magazine, that I think it impossible to do it better.

The wind is fair though but little, it comes well, as if it would stand, therefore up a hand and loose fore-top-sail in the top, that the ships may see we will sail; bring the cable to the capston, heave up your anchor, loose your fore-sail in the brails, put abroad our colours, loose the mizen in the brails, is all our men on board? those that be on shore may have a tow, and be blest with a ruther; for we'll stay for no man: come my hearts, heave up your anchor that we may have a good prize; come, who says Amen? one and all; O brave hearts, the anchor is a peek; heave out fore-top-sail, heave out main-top-sail, hawl home the top-sail-sheets, the anchor is away, let fall your fore-sail, hoise up your fore-top-sail, hoise up your main-top-sail; up and loose the main-sail, and set him; loose sprit-sail, and sprit-sail-top-sail: a brave gale, bring the fore-tack to the cat-head, and trim our sails quartering; hoise up our small sails, heave out the mizen-top-sail and set him; now we are clear, and the wind like to stand; hoise in our boats; before it is too much sea, aboard main-tack, aboard fore-tack, a lee the helem handsomly, and bring her too easily, that she may not stay; brace the fore-sail and fore-top-sail to the mast, and hawl up the lee bowlines, that the ship may not stay; pass ropes for the boats on the lee-side, and be ready to clap on your tackle and hoise them in; stow them fast, let go the lee bowlines of fore-sail, and weather braces: right your helm, hale aft the fore sheet, trim the sails quartering as before; loose sprit-sail and hawl aft the sheets, and hoise up the sprit-sail, top-sail, and other small sails: set the main stay-sail, and fore-top-sail-stay-sail, and mizen-stay-sail, and main-top-sail-stay-sail, and lace on your bonnets, that we may make the most of our way to our station; clear your ropes: come get up our steering-sails, the lee steering-sails of main-sail, and main-top-sail, fore-sail, and fore-top-sail only, for they will sit fairest, and draw most. Thus you have a brave ship under all her sails and canvass, in her swiftest way of sailing upon the sea; and now let us have her right.

Right afore the wind and a freſh gale.

The wind is veered right aft, take in your fore and fore-top-ſail, ſteering-ſail, and fore-top-ſail, and main-top-ſail-ſtay-ſails; for they are becalmed by the after ſails, and will only beat out; the wind blows a freſh gale, round aft the main ſheet, and fore ſheets, ſquare your yards; take in your main and main-top-ſail ſteering ſails; unlace your bonnets, take in your main and fore-top-gallant-ſails; in ſprit-ſail, and mizen-top-ſail, let go the ſheets, hawl home your clew-lines, caſt off top-gallant bow-lines. Thus you have all the ſmall ſails in, and furled when it blows too hard to bear them.

The wind veereth forward and ſcanteth.

The wind ſcanteth, veer out ſome of your fore and main-ſheets, and ſprit-ſail-ſheets, and let go your weather braces; top your ſprit-ſail-yards: the wind ſtill veereth forward; get aboard the fore and main tack, caſt off your weather ſheets and braces, the ſails are in the wind, hawl off main and fore ſheets, the wind is ſharp, hawl forward the main bowline and fore bow-line, and hawl up the main-top-ſail and fore-top-ſail bow-line, and ſet in your lee braces, and keep her as near as ſhe will lie. Thus you have all the ſails trim'd ſharp, and by a wind.

The wind blows friſking.

The wind blows hard, ſettle your fore and main top-ſails, two thirds of the maſt down, it is more wind, come hawl down both top-ſails, cloſe, come, ſtand by, take in your top-ſails, let go the top-ſails, bow-lines, and lee braces, let go the lee ſheets, ſet in your weather braces, ſpill the ſails, hawl home the top ſail clewline, ſquare the yard. Now the top-ſails are furled, and you have the ſhip in all her low ſails, or courſes.

It blows a ſtorm.

It is like to overblow, take in your ſprit ſail, ſtand by to hand the fore-ſail: caſt off the top-ſail ſheets, clewgarnets, leech-lines, buntlines, ſtand by the ſheet, and brace, lower the yard and furl the ſail, here is like to be very much wind, ſee that your main hallyards be clear, and all the reſt of your geer, clear and caſt off. (It is all clear) lower the main yard, hawl down upon your down hawl: now the yard is down, hawl up the clewgarnets, lifts, leechlines, and buntlines, and furl the ſail faſt, and faſten the yards, that they may not traverſe and gall. Thus have you the ſhip a trie under a mizen.

A very hallow grown ſea.

We make fowl weather, look the guns be all faſt, come hand the mizen: the ſhip lies very broad off, it is better ſpooning before the ſea, than trying or huſling: go reef the fore-ſail and ſet him: hawl aft the fore-ſheet: the helm is hard a weather, mind at helm what is ſaid to you carefully: the ſhip wears bravely: ſteddy, ſhe is before it: belay the fore down

hawl:

hawl: it is done: the sail is split: go hawl down the yard, and get the sail into the ship, and unbind all the things clear of it: starboard, hard up, right your helm, port, port hard, more hands, he cannot put up the helm: a very fierce storm, the sea breakes strange and dangerous: stand by to hawl off upon the lanniard of the whip-staff, and help the man at helm, and mind what is said to you: shall we get down our top-mast? no let all stand, she scuds before the sea very well, the top-mast being aloft the ship is the wholesomest, and maketh better way through the sea, seeing we have sea room. Thus you see the ship handled in fair weather and foul, by and large: now let us see how we can turn to windward.

The storm is over, let us turn to windward.

The storm is over, set foresail and main-sail, bring our ship to: set the mizen, the main-top-sail, and the fore-top-sail: our course is E. S. E. the wind is at south; get the starboard tack aboard, cast off your weather braces and lifts: set in the lee braces, and hawl forward by the weather bow-lines, and hawl them tight and belay them, and hawl over the mizen tack to windward: keep her full, and by as near as she will lie: how wind you? east a quade wind: no near, hand no near, the wind veereth to the eastward still: how wind you? N. E. hard, no near, the wind is right in our teeth: no near still; how wind you? N. W. by N. the wind will be northerly, make ready to go about: we shall lie our course the other way, no near, give the ship way, that she may stay: ready, ready, a lee the helm, let go fore-top-bowline, veer out the fore sheet, cast off the lee-braces off your fore-sail and fore-top-sail, brace in upon your weather braces: the fore-sails is a back stays: hawl main sail, hawl, let rise the main tack: cast off your larboard braces: let go main-bowline, and main-top-sail bowline: brace about the yard, hawl forward by the lardboard bowlines: get the main tack close down in the chess-tree: the sheet is close aft, hawl off all: hawl, get to fore tack, let go fore bowline, and fore-top-sail bowline: hawl aft the fore sheet, hawl tight the main bowline, and main-top-sail bowline: shift the mizen tack, hawl tight fore bowline, and fore-top-sail bowline: set in the lee braces fore and aft, keep her as near as she will lie: no near, how wind you? N. N. E. Thus, ware no more, no near, keep her full; the wind is at N.N.E. Thus, ware no more, how wind you? E. N. E. the wind is at N. keep her away her course E. S. E. cast off the lee braces, and weather bowlines, and set in your weather braces, veer out the main sheet, and fore sheet, loose the sprit sail, and sprit-sail-top-sail, and mizen-top-sail, and top-gallant-sails, hoise them up, the wind veers off still, let rise the fore tack: the wind's quartering,

ing, hawl aft the fore ſheet, bring it down to the cat-head with a paſs-a-ree: ſteddy in your weather braces: the wind ſtands. Thus you have the ſhip as at firſt, ſteering under all her canvaſs, quarter wind: ſhe hath been wrought in all manner of weather, and all ſorts of winds: therefore we will draw to a concluſion with a man of war in chaſe and taking of her prize, and ſo leave this practick part to your cenſure.

The man of war in her ſtation.

Now we are in our ſtation, and a good latitude, hand your top-ſails, and furl your main-ſail and fore-ſail, and brail up the mizen, and let her lie at hull, until fortune appear in our horizon: up aloft to the top-maſt-head, and look abroad, young men, look well to the weſtward, if you can ſee any ſhips that have been nipt by the laſt eaſterly winds: *a ſail, a ſail,* where? *fair by us*: how ſtands ſhe? *to the eaſtward, and is two points upon our weather bow, and hath her larboard tacks aboard*: O then ſhe lies cloſe by a wind; we ſee her upon the decks plainly: a good man to helm: up young men, and looſe the fore-ſail, main-ſail and mizen: get the larboard tacks aboard, heave out the main-top-ſail, fore-top-ſail, and looſe the ſprit-ſail, keep her as near as ſhe will lie: hawl aft the ſheets, and hawl up your bowlines tight, do you ſee your chaſe? *yea*: how wind you? E. N. E. then the wind is at N. hoiſe up your top-ſails as high as you can, heave out ſprit-ſail, top-ſail, and mizen-top-ſail; hawl home the ſheets, and hoiſe them up: a young man looſe the main-top-gallant-ſail and fore-top-gallant-ſail, hawl home the ſheets and hoiſe them up; hoiſe up main ſtay-ſail and mizen-ſtay-ſail, and looſe the main-top-ſail and fore-top-ſail-ſtay-ſails, and ſet them: it blows a brave chaſing gale; the ſhip makes brave way through the ſea, we raiſe her apace: if ſhe keeps her courſe we ſhall be up with her in three glaſſes: no near, keep the chace open with the litch of the fore ſail: ſo, thus, keep her thus; come aft all hands, the ſhip will ſteer the better when you ſit all quiet, by her ſmall ſails, for ſhe is too much by the head, the chaſe is a luſty brave ſhip: ſo much the better, ſhe hath the more goods in her hold: the ſhip hath a great many guns, it may be ſhe is a privateer.

Port, the chaſe is about, come fetch her wake and we will be about her: we ſail far better than ſhe: we have her wake-a-lea the helm, veer over fore-ſheet: every man ſtand handſomely to his buſineſs, and mind the bowlines and braces, tacks and ſheets: hawl main-ſail, hawl: let go main bowline, top-bowline, top-gallant bowline: hawl off all, hawl, ſhift the helm, bring her to, hawl the main-ſheet and fore-ſheet, cloſe aft: ſet in the lee braces, hawl tight the bow-

lines;

lines: the chaſe keeps cloſe upon a wind: keep her open under our lee. Gunner, ſee that you have all things in readineſs, and that the guns be clear; and that nothing peſter our deck. —Down with all hammocks and cabbins that may hinder and hurt us. Gunner, is all our geer ready? is there ſtore of cartridges ready filled, all manner of ſhot at the main-maſt? is there rammers, ſponges, ladles, priming-irons, and horns, linſtocks, wads, and water, at their ſeveral quarters ſufficient for them? be ſure that none of our guns be cloyed, and when we are at fight, be ſure to load our guns with croſs-bar and langrel, always obſerve to give fire when the word is given. See that there be half pikes and javelins, in readineſs, and all our ſmall ſhot well furniſhed, and all their bandaleers filled with powder, and ſhot in their pouches: ſee that our murtherers and ſtock-fowlers have their chambers filled with good powder, and bags of ſmall ſhot to load them, that if we ſhould be laid aboard, we might clear our decks. Starboard, the chaſe pays away more room, ſtarboard hard; veer out ſome of the main-ſheet and fore-ſheet: caſt off the larboard braces, ſteddy, keep her thus: well ſteered, the chaſe goes away room, her ſheets are both aft, ſhe is right before the wind: ſtarboard hard, let riſe main-tack, let riſe fore-tack: hawl aft main-ſheet, hawl aft fore-ſheet: we have a ſtern chaſe, but we ſhall be up with her preſently, for we fetch upon her hand going. The chaſe hawls up her main-ſail and furls it, ſhe puts aboard her waſte cloaths, ſhe will fight us: come up young men and furl our main-ſail, fling our main-yard, with the chains in the main-top: fling our fore-yard, put aboard our waſte cloaths, ſhe will fight us before the wind: I ſee ſhe is full of men, it is a hot ſhip, but deep and fowl: come chearly my hearts it is a prize worth fighting for: the chaſe takes in her ſmall ſails, up aloft and take in our top-gallant-ſails, ſprit-ſail, top-ſail, mizen-top-ſail, and furl the ſprit-ſail, and get the yard alongſt under the bowſprit: ſhe puts aboard her colours, they are blue traverſed with a white croſs, they are French colours, no force: boy, up and put aboard St. George's colours in our main-top: ſtep aft a hand, and put aboard our ancient: call all hands aloft, come up aloft all hands: they are all up captain.

Gentlemen, We are here employed and maintained by his Majeſty King GEORGE, and our country, to do our endeavours to keep this coaſt from piracy and robbers, and his Majeſty's enemies; and it is our fortune to meet this ſhip at this time: therefore I deſire you in his Majeſty's name, and for the ſake of our country and the honour of our Engliſh nation and our ſelves, for every man to behave himſelf couragious like Engliſhmen; and not to have the leaſt ſhew of a coward; but to ob-

ſerve

ſerve the words of command, and do his utmoſt endeavour: Into God's hands we commit our cauſe, and our ſelves. So every man to his quarter, and ſhew his courage, and God be with you.

She ſettles her top-ſails, we are within ſhot; let all our guns be looſe in the tackles, and the ports all knockt open, that we may be ready to run out our guns when the word is given. Up noiſe of trumpets and hail our prize; ſhe anſwereth again with her trumpets: hold faſt gunner, do not fire till we hail them with our voice; port; edge towards him, he fires his broad-ſide upon us: what chear my hearts? is all well betwixt decks? yea, yea, only he raked us thro' and through; no force, it is his turn next; but give not fire until we are within piſtol ſhot; port, edge towards him; he plies his ſmall ſhot; hold faſt gunner; port right your helm; ſide hath made her deck thin, but the ſmall ſhot at firſt did gall us, clap in ſome caſe ſhot, we will run up his ſide; ſtarboard a little; give fire gunner; that was well done; this broad the guns you are now a loading: brace to the fore-top-ſail, that we may not ſhoot a head; he lies broad off to the ſouthward, to bring his other broad ſide to bear upon us; ſtarboard hard, get to larboard fore-tack; trim your top-ſail; run out your larboard guns; he fires his ſtarboard broad-ſide upon us, he pours in his ſmall ſhot; ſtarboard, give not fire until he fall off, that the prize may receive our full broad-ſide, ſteddy, port a little; give fire, gunner; his fore-maſt is by the board; this laſt broad-ſide hath done great execution; cheery my mates, the day will be ours: he is ſhot a head; he bears up before the wind to ſtop his leaks: keep her thus; well ſteered; port, port hard; bear up before the wind, that we may give him our ſtarboard broad-ſide; gunner, is there great ſtore of caſe ſhot and langrel in our guns? yea, yea, port, make ready to board him; have your laſhes clear, and able men with them: edge towards him when you give fire; bring your guns to bear amongſt his men with the caſe-ſhot; well ſteered; we are cloſe on board; give fire, ſtarboard, well done gunner; they lie heads and points aboard the chaſe; come, aboard him bravely; enter, enter; are you latched faſt? yea, yea, we will have him before we go here hence; cut up the decks; play your hand granadoes and ſtink pots; he cries out quarter; *quarter for our lives, and we will yield up ſhip and goods:* good quarter is granted, provided you will lay down all your arms, open the hatches, hawl down all your ſails and furl them; looſe the latchings, we will ſhear off our ſhip, and hoiſe out our ſhallop; if you offer to make any ſail, expect no quarter for your lives; go with the ſhallop, and ſend aboard the captain, lieutenant, and maſter and mates, with as many more as the ſhallop will carry. So we will leave the man of war and his prize, and to ſecure his priſoners.

Navigation

CHAP. I.

Navigation New Modelled;

O R,

The WHOLE ART performed

B Y A

NEW METHOD:

SECT. I.

Rules and grounds of the method.

IN order to the right underſtanding of this new method of Trigonometry, I ſhall proceed according to the uſual manner, and ſhall, for the help of memory, lay down ſome fundamental rules or axioms, upon which the whole operation depends, and by which all the caſes in Plain Trigonometry, both right and oblique, may be ſolved, without any book, table or inſtrument whatſoever. But before I come to the axioms, I ſhall premiſe, that whenever a ſide and an angle is given, to find another ſide, (which is the firſt and moſt uſeful caſe in navigation) there muſt, firſt be a number found, which I call the natural radius, not only becauſe it is the original, from whence the ſolutions are deduced, but alſo becauſe being found, it produces the ſame anſwer in natural numbers, that the radius or ſine of 90. produces in a ſinical proportion; and this natural radius is thus found.

METHOD the firſt.

Take the angle whoſe oppoſite ſide is either given or ſought, and divide four times the ſquare of its complement to 90 degrees by 300 added to three times the ſaid complement, and then the quotient added to the ſaid angle is the natural radius required; and this rule is univerſally true in all angles from 0 to 90.

METHOD the second.

But because in angles under 45, the complements are above 45, and their squares amount to greater numbers than the squares of the complements of the angles above 45; therefore to render the work as easy, and the contrivance as useful as possible, I shall shew another way to find the natural radius for all angles under 45, and the rule is,

Divide three times the square of the angle (whose opposite side is given or sought) by 1000, the quotient added to 57 : 3, that is $57\frac{3}{10}$) the sum is the natural radius required.

This being premised the rules are these.

RULE the first. In right-angled triangles.

An angle and a side given, to find another side.

The natural radius bears always the same proportion to the hypotenuse that the angle (by which the natural radius was found) bears to its opposite side.

Therefore if the angles and hypotenuse be given, it is; as natural radius to hypotenuse, so the angle to its opposite side. But if the angles and a leg be given, then it is, as the angle to its opposite side, so natural radius to the hypotenuse.

RULE the second. In right-angled triangles.

Two sides given, to find the third.

The hypotenuse is equal in power to the two legs: that is, the square of the hypotenuse is equal to the square of both legs added together; of which see more in Plain Sailing Arithmetical.

RULE the third. In right-angled triangles.

The hypotenuse and a leg given, to find the other leg.

Multiply the sum of the hypotenuse, and given leg by their difference: the square root of the product is the other leg required.

RULE the fourth. In right-angled triangles.

Three sides given to find an angle.

Add half the longer leg to the hypotenuse: then, as that sum to 86, so the shorter leg to its opposite angle.

RULE

RULE the fifth. In oblique triangles.

Three sides given, to find where the perpendicular must fall.

Multiply the sum of the two shortest sides by their difference, and divide the product by the third side, which is the greatest, and upon which the perpendicular is to fall: the quotient added to the greatest side, or subtracted from it, shall be double the greater or lesser segment, on each side of the perpendicular.

Another way.

Add the squares of the biggest and least sides together, and from their sum subtract the square of the middlemost; half the remainder, divide by the biggest side, the quotient is the lesser segment, which subtracted from the whole base, leaves the bigger segment.

See another way in Axiom IV. of Plain Trigonometry.

SECT. II.

Plain sailing by a new method.

I Shall now proceed to some examples in right-angled triangles, applied to Plain Sailing; and here note, that to avoid fractions, I shall propose the given angle always in whole degrees, that being sufficiently exact in all uses in navigation; yea, and a far more exact way, then reckoning by points, half points, or quarter points; one degree being a much smaller part of a great circle than a quarter point of the compass. And I shall make use of degrees rather than quarter points, not only for its exactness, but also because it's a method much in use aboard of the men of war, to reckon the course in degrees, and not in points and quarter points.

CASE I. *Course and distance given, to find the difference of latitude and departure.*

Note, I shall in every case hereof propose the same questions that are inserted in the second example of each case of Plain Sailing Trigonometrical.

A ship sails south 25 degrees, easterly 96 miles; I demand as above.

The operation at large.

Note, Where both legs are required, chuse always to find the lesser first; because the natural radius is more easily found, and then find the longer leg by Rule the Third.

For the departure.

The angle	— —	25
Multiply by it self	— —	25
		125
		50
Square of the angle	—	625
Multiply by	— —	3
The product	—	1875
1875 divided by 1000 is		1.875
To which add	—	57.3
Sum is natural radius		59.175
Or rather briefer	—	59.2
Which is exact enough.		

The rule I.

As natural radius 59.2. to the distance 96: so the lesser angle 25, to its opposite side the departure.

96	596)24000(40
25	·320
480	320
192	
2400	

Nearest which 40 ½ is the departure req.

Then for the difference of longitude by rule III.

Hypotenuse or distance		96.0
The dep. in decimals		40.5
Their sum	— —	136.5
Their difference	— —	55.5
		6825
		6825
		6825
The product	—	7575.75

7575(87
64
167(1175
1169
(6)

The diff. of latit.

The departure is 40 ½ (or in decimals 40.5.) the difference of latitude 87.

CASE

CASE II. *Course and difference of latitude given, to find the rest.*

A ship sails north 38 degrees west, her difference of latitude 120; her distance and departure is required.

Here the side opposite to the bigger angle is given, therefore we must make use of Method I. to find natural radius, because Method II. serves only to degrees under 45.

```
  38     38   414)5776(13 304/414
  38      3       1636
-----------------------
 304    114       394
 174    300
-------------
1444    414
   4
-------------
5776
```

Because the fraction is so great I shall call the quotient 14, which added to the bigger angle 52, the sum 66 is the natural radius.

Then by RULE I.

As 52, the greater angle, to 120 its opposite side: so is natural radius 66, to the distance required.

Then for the departure by RULE III.

```
      120 | Distance     152
       66 | Diff. lat.   120     8704(93 departure
----------|------------------
      720 | Sum        — 272       81
     720  |                     ---------
----------| Difference 32    183)604
     7920 |             ----
          |              544      549
52)7920(152|                    -------
     272  |              816      (55)
     120  |             ----
----------| Product 8704
      16  |
```

The distance 152. The departure 93.

CASE III. *Course and departure given, to find distance, and difference of latitude.*

A ship sails north 19 degrees easterly, her departure 72 miles; I demand as above.

Here the shorter leg is given; therefore I shall find the natural radius by Method II.

Three times the square of the given angle is 1083, this divided by 1000, which is done by cutting off three figures to the right hand, the quotient is 1.083; which because the second figure in the fraction is above 5, I add one to the first figure, which is a cypher, and then call the quotient 1.1, which added to 57.3, the sum 58.4, is the natural radius required.	19 19 —— 171 19 —— 361 3 —— 1.083

Then for the distance, by Rule I.

As the angle 19, to its opposite side 72 : so natural radius 58.4, to the distance.

58.4 72 —— 1168 4088 —— 4204.8	19)4204(221 .40 .24 —— 5	The distance required.

Then find the difference of latitude by Rule III.

Distance — 221 Departure — 72 —— Sum — 239 Difference 149 —— 2637 1172 293 —— 43657	43657(209 4 —— 40)03657 409) 3264 —— (393) The root 208, but the fraction being so large, I rather call it 209, the difference of lat. required.

CASE

CASE IV. *Distance and difference of latitude given, to find course and departure.*

A ship sails between the north and east 117 miles, her difference of latitude 102 miles; I demand her course and departure.

For the departure, by Rule III.

Distance —	117	3080(55
Diff. of lat. —	103	25
Sum —	220	105)580
Difference —	14	525
	880	(55)
	220	
Product —	3080	The departure $55\frac{1}{2}$

Then for the Course, by Rule IV.

Hypotenuse or distance	117
Half the longest leg	51.5
Sum — —	168.5

As 168.5 to 86 : so shortest leg, or departure, 55.5, to its opposite angle, the course.

55.5	168.5)4773.0(22	The course 28 $\frac{550}{1685}$ degrees, which is almost $\frac{1}{3}$, *viz.* 28 degrees, 19 minutes.
8.6	1403.0	
333.0	..550	
4440		
47730		

CASE V. *Distance and departure given, to find the rest.*

A ship sails in the south west quarter, 124 miles, her departure

departure 95 miles; I demand her course and difference of latitude.

For the difference of latitude, by Rule III.

Distance	—	124	6351(79
Departure	—	95	49
Sum	—	219	149(1451
Difference	—	29	1341
		1971	110
		438	
Product	—	6351	

The square root of 6351 is 79 or 80 (because the remainder 110 is more than the root) the difference of latitude required.

Then for the course, by Rule IV.

Hypotenuse or distance — —	124 —	124
Longest leg, which here is dep. 95 its half		47.5
	Sum —	171.5

As 171.5, to 86: so the shorter leg (which here is the difference of latitude) 80, to its opposite angle, the complement of the course.

86	171.5)6880.0(40 degrees
80	.0200
6880	20.0

The complement of the course is 40 degrees, and consequently the course is 50 degrees, from the south westerly, and the difference of latitude is 80 miles *fere*.

CASE VI. *Difference of latitude and departure given, to find the course and distance.*

A ship sails in the north west quarter, till her difference of

of latitude be 220 miles, and her departure 108; I demand the rest.

For the distance, by Rule II.

220	108 square of diff. lat.	— —	48400
220	108 square of departure	—	11664
440	864		
44	1080 sum of the squares	— —	60064(245
48400	11664		4

44)200
176
485)2464
2425
(39)

Then for the course by Rule IV.

As 355, to 86 : so 108 to the angle of the course.

108	355)9288(26
86	2188
684	58.
864	
9288	

The distance is 245, and the course 26 $\frac{58}{355}$ degrees, or. 26d. 9m. or N. N. W. some what more than $\frac{1}{4}$ west.

SECT. III.

Oblique triangles, by a new method.

How to solve all the cases in oblique plain triangles, by this new method, without any canon, book, instrument, &c.

IN the solution of Oblique Triangles, by this new method, it is necessary that they be first divided into two right angled triangles, by a perpendicular let fall, in which observe:

Let it fall from the end of a given side, and opposite to the given angle.

By this means, the perpendicular will sometimes fall within, and sometimes without; when it falls within, it falls upon some intermediate part of the base, or longest side; but when it falls without, it falls upon one of the shortest sides continued; in either case, there is two right-angled triangles produced, and then the angles or sides sought are found as if they were parts of a right-angled triangle.

CASE

CASE I.

Given $\begin{cases} \text{the angle at A } 30.0 \\ \text{the angle at B } 45.0 \\ \text{the ſide BC } 290 \end{cases}$ required the ſide A C.

Here the perpendicular falls from the end of the given ſide BC, and oppoſite to the given angle at B; then in Fig. 48. the triangle BDC is given the angle at B; and in the ſide B C, to find the ſide C D, which being found, there is given in the triangle ADC, the angle at A, and the ſide DC, to find AC, the ſide required.

I ſhall not trouble the reader with the operation for finding natural radius, it having been often enough repeated in the former part; but being found by Method I. the natural radius for the angle 45 is 63.62; therefore, as 63.62, to ſide CB, 290; ſo 45, the angle at B, to ſide oppoſite CD.

```
  45        63.62)13050.00(205.   The ſide CD 205.
 290           . .326.00
-----       -----------
 4050            . . 790
 900
-----
13050
```

Now in the triangle ADC, is given the angle at A 30d. 0m. and the ſide DC 205, to find AC.

The natural radius found by Method II. for the angle 30 is 60. Therefore,

As the angle at A 30, to ſide oppoſite DC, 205 : ſo 60 to the hypotenuſe AC required.

```
 205       30)12300(410     The ſide AC required.
  60          .3.
-----         .00
12300         ..
```

CASE II.

Given $\begin{cases} \text{the ſide AB } 560 \\ \text{the ſide AC } 410 \\ \text{the angle B } 45.0 \end{cases}$ required the angle at C.

Here

Here the perpendicular falls without, upon the side BC continued, and in the triangle BDA there is given the angle at B 45, and the hypotenuse AB 560, to find AD, which being found you have given in the triangle CAD, the hypotenuse C A, and the leg A D, to find the leg CD, and the angle DAC; and by subtraction, the angle DCA, and the angle BCA. in their proper case of right-angled triangles. Fig. 49.

The operation.

The natural radius for the given angle 45, is 63.62, as found by Method I: therefore, as 63.62 to the hypotenuse 560; so the angle at B 45, to side opposite AD.

560	63.62)25200.00(396 the side AD.
45	6114.0
	388.20
2800	
2240	..6.48
25200	

Then you have AD 396, and AC 410, to find CD by Rule III. thus:

Side AC —	410	. . .
Side AD —	396	11284(106, the leg CD.
		1
Sum — —	806	
Difference —	14	20)012
		00
	3224	
	806	206)1284
		1236
Product —	11284	
		(48)

Then for the angle CAD. by Rule IV.

Hypotenuse AC —	410	As 608 to 86, so 106 to the angle CAD.	
Half of the leg AD	198		
Sum — —	608	106	608)9116(14$\frac{604}{608}$
		86	3036
		636	604
		848	
		9116	

The

The angle CAD is 14 $\frac{604}{808}$ or rather 15 degrees; which subtracted from 90, leaves ACD, 75 degrees; and that subtracted from 180, leaves 105 degrees, the angle ACB required.

CASE III. *Given as in case* II. *to find the third side* BC.

In the whole triangle BDA, you have given the angle ABD 45, and the hypotenuse BA 560; also by consequence, the angle ABD, which is also 45, to find the whole side BD; but in this case the acute angles being equal, *viz.* 45 degrees, the leg BD is equal to AD, *viz.* 396; then having found CD 106, by the second operation in Case II. subtract it from the whole side BD 396, the remainder 290 is the side BC required.

CASE IV.

Given $\left\{\begin{array}{ll}\text{the side AC} & 410\\ \text{the side AB} & 560\\ \text{the angle at A} & 30.0\end{array}\right\}$ required the angle at B.

In the triangle AEC, is given the angle at A 30, and the hypotenuse AC 410, to find CE, which by the first case hereof is found to be 205, and therefore I need not repeat the operation. Then in the same triangle ACE, there is given the sides AC 410, and CE 205, to find the side AE by Rule III. Fig. 50.

AC — —	410	126075)355, the leg AE.
CE — —	205	9
Sum — —	615	65)360
Difference —	205	325
	3075	705)3575
	12300	3525
Product —	126075	50

The leg AE 355 subtracted from the whole side AB 560, rest EB 205; then in the triangle BEC, you have given BE 205, and EC 205, to find CB by Rule II. and the angle B by Rule IV. but in this case, EC and EB being equal, the angle at B is proved 45 degrees, without calculation.

CASE

CASE V.

Given as in case IV. *to find the third side* BC.

Although this is the fifth Case in the Trigonometrical operation, yet the side BC is necessarily found in Case IV. before the angle at B can be found; and therefore, although the operation in Case IV. be somewhat tedious, yet both the fourth and fifth Cases are included in it.

CASE VI.

Given { AB — 560, AC — 610, BC — 290 } required the angle at A.

Find AE by the rule laid down in Axiom IV. of Plain Triangles. As the base AB 560, to the sum of the other two sides, 700 : so the difference of the said sides 120, to the difference of the segments of the base AD 150, as by the operation below. Fig. 51.

120	56.0)8400.0(150
700	280
84000	..000

To the half diff. 75 add the half base 280, the sum 355 is the greater base AE; but subtracted, the difference is the lesser base EB 205.

Then in the triangle AEC, there is given AC 410, and AE 355, to find CE by Rule III. and the angle at A by Rule IV.

The side AC	—	410
The side AE	—	355
Their sum	—	765
Their difference	—	55
		3825
		3825
Product	—	42075

42075(205
405)02075
2025
50

The square root of 42075, *viz.* 205 is the side CE required.

Then, by Rule IV. find the angles at A.

Hypotenuse

Hypotenuse —	410
Half the longest leg	177.5
Their sum —	587.5

As 587.5 to 86 : so CE 205, to the angle opposite at A 30.

```
 205      587.5)17630.2(30 The angle at A req.
  86            ...5
 ----     -----------
 1230           50
1640
-----
17630
```

Although this method be not altogether so expeditious for oblique triangles, as the calculation by logarithms, because you are obliged to divide every oblique triangle into two right-angled ones, which sometimes requires two operations; yet I thought fit to insert it to make the method compleat, it being of great use when tables are wanting, and of sufficient exactness for most uses in navigation; but the right-angled cases, as performed hereby, I shall recommend to the reader, as a thing very useful, sufficiently exact, and as expeditious as any method commonly in use.

SECT. IV.

How to find the difference of longitude, and keep a reckoning both in latitude and longitude, by this new method of trigonometry, (as applied to navigation) without the help of any tables or instruments whatsoever, according to middle latitude, which is of sufficient exactness for the working so short a distance as a day's run, and consequently of great use in navigation.

YOU may remember, that in Middle Latitude Sailing Trigonomical, there is a proportion for finding the difference of longitude: which is, as sine complement of middle latitude, is to the departure; so is radius, to the difference of longitude. And therefore in Middle Latitude Sailing Geometrical, one way which I have proposed for projecting Middle Latitude Sailing, is, by constituting a right-angled plain triangle, whose angle at the base is equal to the complement of middle latitude, and the perpendicular is equal to the departure: and then by that known pro-

proportion of opposite sides, opposite angles, it will necessarily follow, that the hypotenuse must needs represent the difference of longitude; which being granted, there is no more to do for finding the difference of longitude, but only the solution of the said right-angled triangle; of the several varieties of which you have had sufficient instances in the six cases of Plain Sailing before going, where any two parts being given, the other two are easily found. Nevertheless, that nothing may be wanting for the reader's instruction, I shall instance in one question for example's sake, which I shall first work by this new method, and then by the method proposed in Middle Latitude Sailing Trigonometrical; and lastly; shall work the same by Mercator, to let the reader see the sufficiency and exactness of this new and useful invention.

Question. A ship in latitude 58d. 0m. north, sails south 25 degrees, easterly 96 miles: I demand the latitude come to, and also her departure and difference of longitude.

The course and distance is the same as in the question in Case I. of Plain Sailing, as performed by this new method, and therefore I shall refer you to the operation there for finding the difference of latitude and departure. The difference of latitude being there found to be 87, and the departure $40\frac{1}{2}$ or 40.5. and therefore (the course being southerly) the latitude come to is 56d. 33m. and consequently the middle latitude, found by the direction and caution laid down in Case I. of Middle Latitude Sailing Trigonometrical is 57d, 17m. and the complement of middle latitude is 32d. 43m. From hence, by the foregoing directions, is constituted the triangle A B C; wherein the angle at A is equal to the complement of middle latitude 32d. 43m; and the side opposite BC, is equal to the departure 40.5; both which are given to find the hypotenuse AC, equal to the difference of longitude required; and here the side opposite to lesser angle being given, I shall find natural radius by Method II. And here observe, that although in questions of Plain Sailing, you need not regard minutes in the angle of the course, because whole degrees are exact enough to keep account of a ship's way; yet in this case you must not omit the odd minutes in the angle; and therefore reduce the odd minutes to tenths of a degree, accounting 6 minutes for one tenth of a degree, and 12 for two tenths, &c. And then 42 minutes is 7 tenths; and this angle being 32d. 43m. I shall call it 32.7, *viz.* 32 and 7 tenths, it being but one minute more, which cannot cause any great error in the operation.

Fig. 52.

For

For fiding natural radius, by Method II.

The angle — —	32.7
Mult. by itself —	32.7
	228.9
	654
	981
Sq. of the angle	1069.29
Mult. by — —	3
The product —	3207.87

Divided by 1000, the product is 3.207, but it is exact enough to call it 3.2, which added to 57.3 the sum is 60.5, the natural radius required.

Then, because the hypotenuse is required, the proportion is,

As the angle 32.7 is to its opposite side 40.5; so is natural radius 60.5, to the hypotenuse

60.5	327)24502(74$\frac{304}{327}$
40.5	1612
30.25	304
2420.0	
2450.25	

The product of the multiplication is but 2450, the other two figures being but a decimal fraction, are to be cut off; but because the divisor 32.7 is a decimal, I add one figure to the dividend, as you see in the operation above.

The difference of longitude is 74$\frac{304}{327}$, which without exactly regarding the fraction, may be set down 75: and this operation may be performed with great ease and readiness, with a little practice, although I have here set it down in words at large, to make it more intelligible.

The same question answered by middle latitude sailing trigonometrical.

FIND difference of latitude and departure, and consequently the latitude come to, with middle latitude and complement of middle latitude as in Case I. of Middle Latitude Sailing Trigonometrical, which will be found to be as above expressed.

Then for the difference of longitude.

	d.	m.	
As sine comp. mid. lat. —	32	43	— — 9.73278
Is to the departure —		40.5	— 1.60745
So is the radius —	90	00	— 10.00000
To the diff. of longitude		74.9	— — 1.87467

The

The foregoing question answered by Mercator's sailing.

FIND difference of latitude, and consequently the latitude come to, as in Mercator's Sailing Trigonometrical, and you will find the latitude come to is 56d. 33m. and the departure $40\frac{1}{2}$ or 40.5.

Latitude sailed from —	58d. 00m.	merid. parts	4294
Latitude come to —	56d. 33m.		4133
Meridional difference of latitude — —			161

Then,			co. ar.
As proper difference of latitude	87	— —	8.060481
To merid. diff. of latitude	161	— —	2.206826
So is the departure —	40.5	— —	1.607455
To the difference of longitude	74.9	—	1.874762

And thus you see the exact agreement of this with the true operation, as performed by Mercator's Sailing; it not differing from it so much as one quarter of a minute in longitude, in so great a distance as 123 miles, and in a latitude so near the pole as 58 degrees, where there is much more danger of contracting an error than in lesser latitudes, or voyages nearer the equinoctial.

CHAP. II.

Practical Navigation; or the application of the foregoing rules to the actual keeping of a reckoning, according to the several kinds of Navigation.

THERE are four things very necessary to be known by all that take upon them the charge of conducting a ship from one part of the world to another, which may properly be called the practical part of navigation.

The first is a right understanding of the compass, with the variation thereof, in order to the true knowledge of the course made good.

The second is the log-line and half minute glass, that the knots on the log-line be a due length, and that the glass be a just

a juſt half-minute, that thereby you may as near as poſſible find the true diſtance.

The third is the right manner of taking and working an obſervation by the ſun by day, or by the ſtars by night, thereby to find the true latitude, and to correct the dead reckoning, if there have been any error contracted either in the courſe or diſtance.

And, fourthly, having by theſe means and helps finiſhed your reckoning, and being come near the deſired port, it is alſo neceſſary, that there be a right underſtanding of the tides, which way the ebbs and floods ſet, and what moon makes full ſea upon any coaſt, that ſo it may be known how long to ride at anchor, or lie by to wait the tide, if you know you be too ſoon; or what ſail to make to ſave your tide, if you fear being too late: and theſe four things I ſhall handle in this part, and that in ſuch a manner, as may be intelligible to the meaneſt capacity, and moſt uſeful as well as moſt eaſy to be put in practice at ſea.

SECT. I.

Of the variation of the compaſs.

THE way commonly taught for finding the variation of the compaſs, is by the ſun's azimuth, or amplitude? but theſe ways not being attainable by any but them that have learned ſomething of aſtronomy; and being alſo treated of in other books, I ſhall not trouble the learner with them, but proceed to a far eaſier way, which is this:

When you are at ſea, and deſire to know the variation of the compaſs, take your quadrant about 8, 9, or 10 a clock, when you ſuppoſe the ſun is near about half up from the horizon to the meridian, and take an obſervation of the ſun's altitude, as you would do at noon to find the latitude of the place; which being done, lay by your quadrant (letting the vanes remain unremoved) and by your azimuth compaſs (if you have one on board) ſet the ſun, and mind what point of the compaſs the ſun is upon at that obſervation. This done, wait till the afternoon, that the ſun grows almoſt as low as he was when you obſerved in the forenoon, and then with your vanes fixed as in the firſt obſervation, obſerve till the ſun be ſo low as that the vanes ſo fixed will juſt take the ſun's altitude without altering them; which done, obſerve immediately (as before) upon what point of the compaſs the ſun is at that obſervation: then the ſpace between that point which the ſun was upon at the firſt obſervation,

tion, and that point upon which the ſun was at the laſt obſervation, divided into two equal parts, the middle is the true ſouth point of the compaſs, and the diſtance between that and the ſouth point of the card, is the variation required.

Example.

Suppoſe at the forenoon obſervation I find the ſun by the compaſs to be ſouth-eaſt (it matters not what his altitude be, ſo you mind what it be, or elſe let the vanes ſtand unremoved till the afternoon) and ſuppoſe in the afternoon I find, when the ſun hath the ſame altitude, that he bears weſt ſouth weſt; now the diſtance between ſouth eaſt and weſt ſouth weſt, is ten points, the half of that is five points, which reckoned from ſouth eaſt towards the weſt ſouth weſt, it falls upon the ſouth and by weſt; therefore I conclude that the ſouth and by weſt point of the compaſs points to the true ſouth point, and the diſtance between the ſouth and by weſt point (which is the true ſouth) and the ſouth point of the compaſs (which we may call falſe ſouth, or magnetical ſouth) is the variation of the compaſs; and becauſe the magnetical ſouth is eaſtwards from the true ſouth, therefore the magnetical north is weſtward from the true north. Hence I conclude, that the variation is one point weſterly, &c.

In this caſe there is only this caution to be obſerved, *viz.* that this obſervation be not made when the ſhip is running very faſt northwards or ſouthwards, which may make ſome ſmall error, though ſcarce diſcernible; for if the ſhip ſtood ſtill, the ſun would have exactly the ſame altitude at 8, 9, 10, in the forenoon, that it would have at 2, 3, 4, in the afternoon; but if the ſhip ſails very faſt to the ſouthward in north latitude, or to the northward in ſouth latitude, ſhe raiſeth the ſun a little, and by conſequence the ſun will be ſomewhat higher at 4 in the afternoon than at 8 in the morning, and may cauſe ſome error, but it is little, and a thing that ſeldom happens: and if it do happen that your courſe be north or ſouth, and the wind ſo fair, you may refer your obſervation till another day, (it being not neceſſary to ſet the variation every day) and thereby the error may be avoided, and yet the variation exactly found as often as it is neceſſary.

Note, I ſhall ſhew how to find the variation by the ſun's azimuth and amplitude hereafter in the aſtronomical part.

SECT. II.

How to divide the log-line, and try a half-minute glass.

THEY that take upon them to be master, mate, or pilot of a ship, and would be very exact and accurate in the keeping a reckoning or account of the ship's way, ought to take care before they go from the shore, to be furnished with all things necessary for that purpose. For the best of scholars, the greatest artists, the most profound mathematicians, or the most experienced navigators, may be deceived, and carried into gross errors, by a defect in their instruments, or means for keeping a reckoning, as well as the more ignorant may be by a defect in their knowledge; and so far as they design that their account shall depend upon their dead reckoning, they ought chiefly to be careful in these two things.

First, the half-minute glass, that it be of a due length; for if it be longer than it should be, it makes the ship by estimation to run so much more than indeed she does, and by that means, perhaps, in a month or 6 weeks sailing, you will expect to arrive at your port, or make such or such land, when indeed you are 50, 60, or 80 leagues, or more or less short of it, according as the error of your glass is more or less. And although it is hard to know a true half-minute glass, yet there are these two ways to prove them, and know whether they are right or wrong.

The first way is by an experiment mentioned by Mr. Henry Phillips, in his Advancement of the Art of Navigation, and also quoted by Seller, in his Practical Navigation, and 'tis this: take a bullet of any competent weight, it matters not, and make fast to it a piece of fine thread, or silk, of the just length of $38\frac{1}{2}$ inches; let there be a noose on the end of the thread, and let the very end of the noose be just $38\frac{1}{2}$ inches from the center of the bullet, (as I said before) then hang it up by the noose upon a small pin, where it may hang at liberty, and swing freely, and so give it way, and each swing shall be a true second of time; that is, each time that it passes by the perpendicular let fall from the pin on which it hangs, shall be a second; and every time of its return to the place where it first begun its motion, is two seconds of time, and a glass that runs till the said bullet hath made 30 swings shall be a true half-minute glass.

A second

A fecond way (if it may properly be fo called) is by the experience of thofe that have had occafion to ufe a glafs in long voyages; and having a line rightly divided, by a glafs of fo true a length, that their dead reckoning, when carefully kept, hath agreed with the truth of their obfervations; and that their making of land, *&c.* hath fallen out according to expectation, by the dead reckoning; I fay fuch a glafs, or another of the fame length, ought to be preferred before any other, as a true half-minute glafs.

A fecond thing neceffary, in order to the keeping of a true reckoning, is to take care that the log-line be rightly divided; for although the glafs be true, yet if the log-line be divided into knots too long or too fhort, it muft needs make an error in the reckoning, according to the proportion of the error in divifions of the line, if you work by a true half-minute glafs. Indeed, if the divifions of the log-line be too fhort, and the glafs alfo too fhort, (or if both be too long, which is the fame) then the one error helps to compenfate the other; but if the faults in the line and in the glafs be contrary, that is, the one too long, and the other too fhort, the fault is intolerable.

As for the length of each knot on the log-line, or how it fhould be divided, there are different opinions, amongft different authors and navigators. Indeed it is an undeniable truth, and apparent to all men's reafon, that one knot upon the log-line fhould be the 120th part of a mile; becaufe half a minute is the 120th part of an hour; (for as the whole to the whole, fo a part to the part, *&c.*) but the difficulty arifes from the different opinions, as to how many feet, yards, *&c.* there is in one degree of a great circle upon the earth. Mr. Oughtred, in his circles of proportion, will have $66\frac{1}{4}$ miles to anfwer one degree upon the earth, each mile containing 5280 feet. Hence there is by his account, 349800 feet in one degree of a great circle upon the earth, and 5830 feet in one minute, or 60th part of fuch a degree, and confequently the 120th part of a minute, or length of one knot upon the log-line, muft be $48\frac{7}{12}$ feet.

But Mr. Norwood, in his Seamen's Practice, p. 43. (relating an experiment of his for finding the quantity of one degree of a great circle upon the earth) faith, that one degree contains 367200 of our Englifh feet to a degree, which account, without any allowance, would give 51 feet to one knot of the log-line, although, for reafons there mentioned, he allows 1 foot out of the 51, and fo would have one knot of the

the log-line to be just 50 foot: but how far that experiment of his is to be depended upon, (considering the unevenness of the ground, and crookedness of the way, and other inconveniences, which he could only give allowance for according to his judgment) and also how far that one foot in 51 may compensate the way that the log makes after the ship, I shall not take upon me to determine. In the mean time I shall, with submission to better judgments, rather adhere to the way of dividing the log-line that is commonly received and used by most mariners, I mean that of 42 feet, or 7 fathom to one knot. Now it will presently be objected, that according to that division for half a minute, multiplying that by 120, for 1 mile, and that product by 60, for 1 degree, there is by consequence but 302400 feet in a degree which seems to contradict, and intolerably to vary from the opinions of the ingenious Mr. Norwood, and other experienced men in that kind.

I answer, it doth not contradict them, at least so much as at first appearance it seems to do: for one grand reason why I agree to these shorter divisions is, to give allowance for the way that the log makes after the ship; for although there is so much stray line allowed, as may be supposed to veer the log moderately well out of the eddy of the ship's wake, yet it cannot be supposed, but that still the log must have some way after the ship, but if by the weight of the line, which although but light, yet the water being but a soft fluid substance, the log must needs have a motion after the ship, especially sailing large, and in a fresh gale, it cannot be but that the wind will have so much effect upon the log, and so much of the superficial part of the water, as to shove it along after the ship, and that, in my opinion, much more than one foot in 51.

Indeed another consideration, which may be accounted a second reason why I do adhere to that way of dividing the line, is, because if there is an error, it is on the safer side; for although the truth is best, if it could be attained, yet if an error must be, 'tis better that the reckoning be a-head of the ship, than that the ship should be a-head of the reckoning; and better to look out for land before we come at it, than to be a-shore before we expect it.

But

But my third reaſon is, the confirmation of this my opinion, by the daily practice and experience of many, if not moſt mariners, who uſe this way, and find the ſucceſs to anſwer their expectations, at leaſt much nearer than a much larger diviſion would do. 'Tis true, if the generality of glaſſes be ſo much too ſhort, as to countervail thoſe too ſhort diviſions (if they are too ſhort) it were to be wiſhed, that the errors in one were rectified, and then the faults in the other might be amended; but till then I ſhall recommend that way of following 42 feet, or 7 fathom, to one knot of the log-line. Indeed if it be, as it is reported by ſome, that to make amends for the ſhortneſs of the knots, the glaſſes are commonly made but 27 ſeconds: and if ſo, then if the glaſſes were regulated and increaſed from 27 ſeconds to 30, the knots, by the ſame proportion, ſhould be alſo increaſed from 42 feet to 46⅔ feet to one knot, which ſeems more agreeable to reaſon, and to Mr. Norwood's obſervation.

Note, When you divide the log-line you muſt allow 12, 15, or 18 fathom of ſtray-line, according to the bigneſs of your ſhip, accounted from the log, before you begin to ſet out the knots, and there put in a red or white rag, and from thence begin to divide the line into knots. The reaſon of the ſtray-line is to veer the log pretty well out of the ſhip's wake, leaſt the eddy ſhould ſuck the log after the ſhip, and deceive you in your reckoning.

SECT. III.

How to make a plain chart.

THE log-line being thus divided, and the half-minute glaſs examined and regulated, the next thing is to make a chart for the voyage intended; and of charts there are ſeveral ſorts.

The firſt is commonly called a plain chart, in which the degrees of longitude and latitude are every where equal, without any reſpect to the globularneſs of the earth, but rather ſuppoſing the earth and ſea to be a plain ſuperficies; and hence it is, that this projection is falſe, except in places under or near the equinoctial. However it being much in uſe, I ſhall lay down the projection of it as followeth.

If you would make a plain chart for all the earth and ſea, 'tis beſt to do it upon two ſheets of paper; one half upon each ſheet. Through the middle of each ſheet, croſs-ways from the right-hand to the left, draw the ſpotted line A B, which divide

divide into 180 equal parts, by any equal parts of the scale, as large as your paper will contain, which you may mark at every 10 degrees with figures, 10, 20, 30, *&c.* to 180, beginning at any place where you intend to reckon your longitude from, which suppose let be London, let your chart begin at the west or left-hand, and so reckon eastwards, as in the following example, where the two charts contain all the 360 degrees of longitude in compass, and 90 degrees of latitude each way from the equinoctial. Then from the middle of the chart, as a center, draw the 32 points of the compass, as you see done. Then for inserting any known place in the chart, find by the table of latitude and longitude of places what latitude and longitude your place hath, and place it in that latitude
Fig. 6, 7. and longitude in the chart; as for example, suppose I would insert the land's end of England, and the west end of Cyprus in the Straits and would find their bearing and distance; according to the plain chart, I find the latitude of the land's end of England in the table is 49d. 55m. north, and longitude 5d. 14m. W. I reckon upon the line AB, which is the equinoctial, till I come at 5 degrees, *viz.* 5 of the small divisions, and as near as I can compute, somewhat less than ¼ of another small division, for the 14 minutes, and setting one foot of the compasses in that mark, I extend the other to the next north and south line, and running them up into latitude 49d. 55m. I make the mark ⊙ to represent the
Fig. 6, 7. Lizard; and by the same method I find the west end of Cyprus at the mark △, then the distance between these two marks taken in your compass, and applied to the equinoctial line AB, accounting every degree 60 miles, and every 10 degrees 600 miles, gives the distance between the two places, according to the plain chart; and then for the course, observe what line, or point of the compass, a line supposed to be drawn between these two places would be parallel to, which in this case you see is an E. S. E. and W. N. W. line, the nearest point representing the course required.

In like manner you may insert any other place whose latitude and longitude is given; as for instance, I have inserted the following places, which because the draught is too small to contain the name at large, I have represented them by the following letters annexed to them.

⊙ The Lizard.
△ The island of Cyprus in the Straits.
a Majorca, an island in the Straits.
b Barbadoes.

c Jamaica.

c Jamaica.
b Cape Henry in Virginia.
o Bengal, in the East-Indies.
d Cape Bona Esperanza.
e The Naze of Norway.

These are sufficient to let the learner see how to set down the places in a plain chart.

But suppose you are to sail from any one of these places, or any other place, to some other port, it is best to make a chart for the particular voyage, to contain only so much of the earth and sea as is contained between the two places, or little more, and then you make your degrees of latitude and longitude larger, as in the following example.

A ship sets sail from Flamborough-Head, in lat. 54d. 08m. north, and longitude 0d. 10m. W. intending for the Naze of Norway, in lat. 58d. 00m. and long. 6d. 2m. E; I desire a chart made for that voyage?

This chart is made to contain from 54 to 58 of latitude, and from 16 to 21 of longitude; and then by the former rules, the point A represents Flam-borough-Head, Fig. 8. and the point ⊙ upon the opposite corner, is the Naze of Norway: then at Flamborough-Head, the place failed from, as a center, I describe a quarter of a compass, which in this case is always sufficient, and thus is the chart ready for the voyage.

As for setting off the courses and distances, or difference of latitude and departure, upon a chart, commonly called, pricking a chart, I shall refer it till I come to give some examples of keeping a journal by the log and compass.

How to make a Mercator's chart.

A Mercator's chart appears somewhat like a plain chart, only with this difference, that whereas, in a plain chart, the degrees of latitude and longitude are every where equal, it is not so in a Mercator's chart; for in it the degrees of latitude bear the same proportion to the degrees of longitude, that they do upon the globe; and the invention of this chart is most properly owing to our worthy and ingenious country-man, Mr. Edward Wright, as may be seen in his correction of the errors of navigation: however (I know not well for what reason) unjustly ascribed to Mercator. Now although upon the globe the degrees of latitude are every where equal, and the degrees of longitude grows less nearer the poles; yet in this chart it is not so,

ſo, but the meridians are parallels, and every where equal, as in a plain chart; but the degrees of latitude grow bigger near the poles; ſo that in a Mercator's or Wright's chart, there is always the ſame proportion between a degree of latitude, and a degree of longitude, in any parallel, as there is upon the globe itſelf, though the diſtances are extravagantly diſtorted, eſpecially near the poles.

For the projection of this chart, there are two lines upon Gunter's ſcale, commonly placed next the bottom, on that ſide upon which the logarithmetical numbers, ſines, and tangents are; the loweſt of the two is a ſcale of equal parts, and the next to it is called the meridian line, by the help of which, if you would draw a large chart of all the world between 85 degrees of north latitude, and 85 degrees of ſouth latitude, you muſt prepare large paper, or paſte ſheets of paper together, till your ſheet contain about four feet each way; through the middle of which draw the equinoctial line, as you ſee in the plain chart before inſerted, and graduate it with 10, 20, 30, *&c.* by thoſe diviſions upon the line of equal parts now mentioned, which done, when you ſee how far the 180 degrees of longitude reach (if you make the chart in two parts, or the 360 degrees, if you make it all in one draught, as your ſheet of paper four feet ſquare will eaſily contain) and there draw lines at right angles, with the equinoctial line, as you ſee in the foregoing charts, the lines CAE, and DBF. fig. 53. then theſe lines graduated from A the equinoctial, both ways, by the graduations upon the meridian line upon the ſcale, ſhall ſet off every parallel of latitude according to Mercator; and when the lines on both ſides are ſo graduated upwards and downwards, from the equinoctial, the lines drawn from every degree on one ſide to the ſame degree on the other ſide, ſhall repreſent the parallels of latitude required.

But becauſe theſe graduations would be too ſmall to make a chart by, for any particular voyage, it is better to make the chart larger, and in that caſe the want of a meridian line ſo large, may be ſupplied by a table of meridional parts; for having drawn the equinoctial, or any other parallel of latitude, which is the ſame, for one out-ſide of your chart; ſet off 60 of any equal parts for every degree of longitude, both at the top and bottom of your chart; this done, find (by the rules laid down in Mercator's Sailing Trigonometrical) the meridional difference of latitude, or the meridional parts contained between that degree and the next, theſe taken from the ſame ſcale of equal

equal parts, and set from the last degree marked, shall find the next degree, and so in the rest.

The rumbs, or points of the compass, are exactly the same as in a plain chart.

I shall explain what hath been said by an example of a Mercator's chart, from Flamborough-Head to the Naze of Norway before-mentioned.

		Lat.		Long.
Flamborough-Head	—	54d. 8m.	—	0d. 10m. W.
Naze of Norway	—	58 0	—	6 2 E.

It is best to make the chart to a whole degree, and in this example I shall, as before, make it from lat. 54 to 58, and 9 deg. of longitude.

Merid. parts for lat. 58d. 0m.	—	4294
Merid. parts for lat. 54 8	—	3878
Merid. diff. of lat. in the whole chart		416
Diff. of longitude in the whole chart		540

Having drawn the line *d a*, set off the whole meridional difference of latitude 416, off any convenient scale of equal parts from *d* to *a*, and draw *ab*, and *dc*, perpendicular to *da*, and set off the whole difference of longitude 9 degrees, or 540 M. from *d* to *c*, and from *a* to *b*, and draw *cd*; thus you have the whole substance of your chart.

Then set 60 of the same parts from *d* to 0, and from 0 to 1, and from 1 to 2, &c. both upon the line *dc*; and upon the line *ab*, and draw the lines ⊙ 0—0 1—1, &c. thus is your longitude graduated.

Then for the latitude, find the meridional difference of latitude, between lat. 54 and 55, which is 103, therefore set 103 of the same equal parts from *a* to 55, and from *b* to 55, and draw the line 55—55; then find the meridional difference of latitude between lat. 55, and lat. 56, which is 106, which set from 55 to 56, on both sides, and draw the line 56—56, and so find also the line 57—57. Then upon the center A, which represents the place sailed from, draw a quarter of a compass, the rumb upon that compass shews the true course from Flamborough-Head, at the point A, to the Naze of Norway, at the point ⊙, which you see differs much from the course found by the plain chart.

The distance between any two places in a Mercator's chart is

is thus found: find the difference of latitude between the two places, which here is 3d. 52m. or 232 minutes, which set off upon the lines *a b*; take the 3 whole degrees from 17 to 20, and the 52 min. in the graduated degree, accounting every part 10 min. because the degree is divided into 6 parts; then keeping your compasses at that extent, lay a ruler so, as it may just cut the two places, whose distance is required; then set one foot of the compasses at the ruller's edge, so as that the other turned about may just touch some east and west line, then keeping that foot fast that stood against the ruler, open the other to the crossing of the ruler, and the said east and west line, that extent measured on the parallel *a b*, allowing 60 miles to every degree, gives the true distance required.

Fig. 9.

Thus a scale laid from *a* to ⊙, describes the pricked line *a* ⊙, then with 3d. 52 min. in your compasses, and one foot in *b*, the other turned about will just touch the line 57—57; then observe where the line 57—57 cuts the pricked line *a* ⊙, as in *k*, the extent *bk*, measured on the line *ab*, gives the true distance.

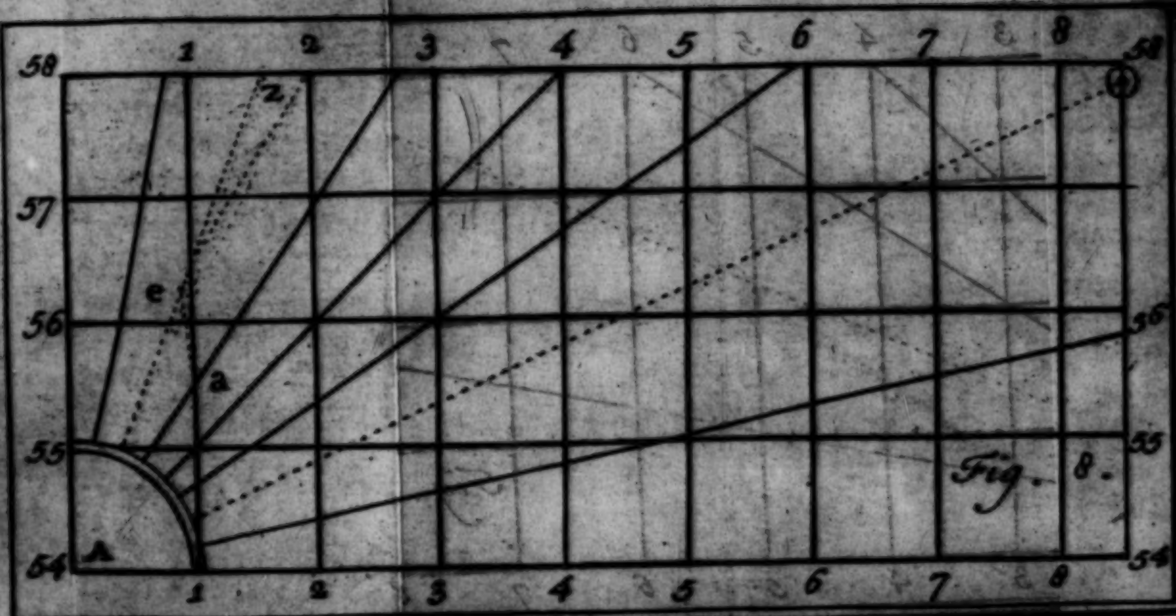
How to make a true plain chart.

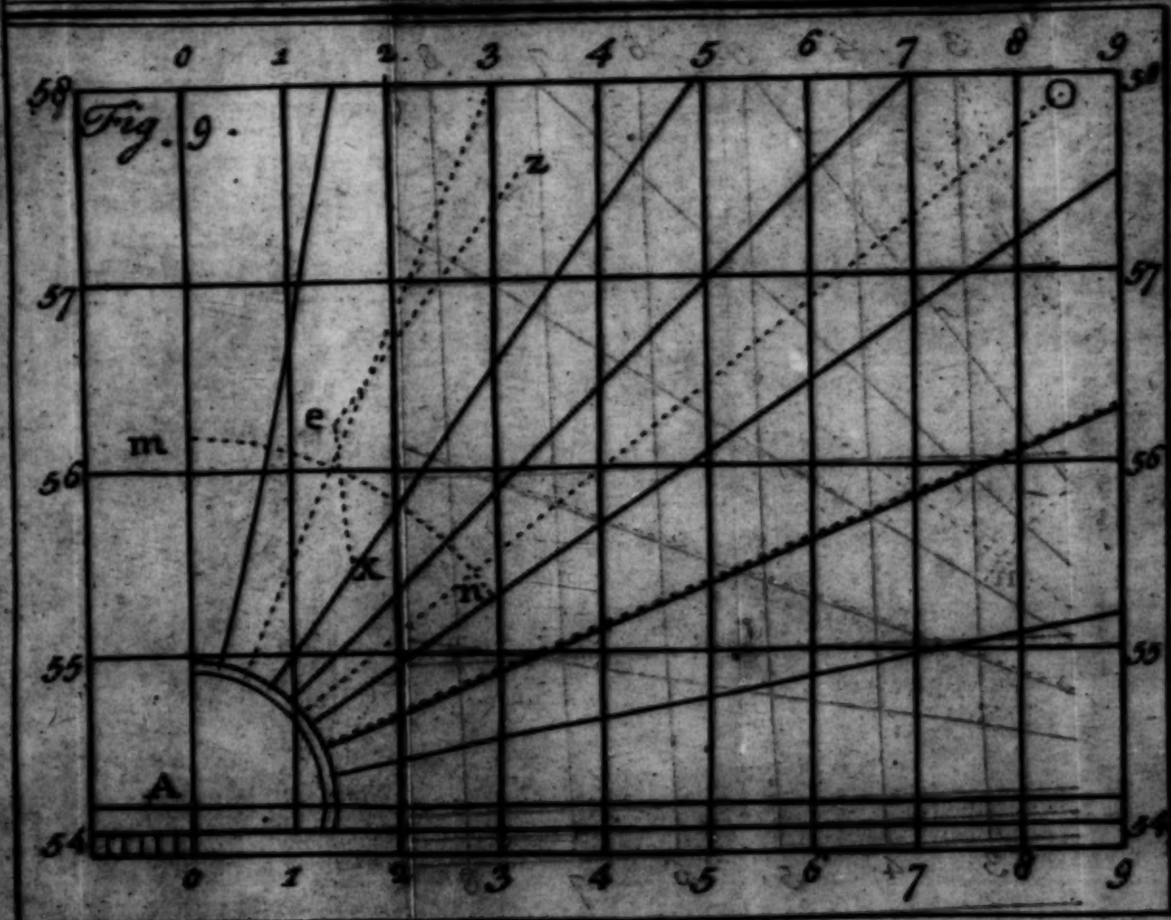
BUT a third sort of charts I shall next describe, which is as true as Mercator's, and yet as plain, easy, and expeditious for practice, as the plain chart, but it cannot be made but for a particular voyage, and generally when you intend to come back the same way you go, and it is thus made.

Having the latitude and longitude of the two places between which you are to sail, find the true course and distance, by case the sixth of Mercator's sailing, which found, set off the course and distance between the place sailed from and the place bound for, as you are taught in Traverse Sailing Geometrical; so have you two points representing the two places, and if your ship sail upon several courses and distances, in form of a traverse, as you are taught in Traverse Sailing Geometrical, and so you may every day set off the course and distance from the ship to the place bound for, according to Mercator, and yet 'tis done as easily as in Plain Sailing. I shall instance in the fore-mentioned voyage.

	Lat.	Long.	
A ship sails from Flamborough-Head	54d. 8m.	0d. 10m.	W.
Intending for the Naze of Norway	58 0	6 2	E.

For





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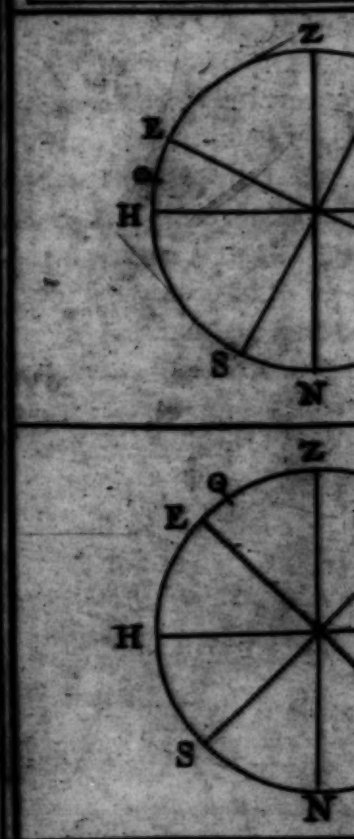

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For the course, according to Mercator.

As merid. diff. of lat.	416	—	2.61909
Is to radius —	90d. 00m	—	10.00000
So is diff. of long. —	372	—	2.57054
To tangent of the course —	41 48	—	9.95145

Then for the distance.

As sine com. course —	41d. 48m.	—	9.87243
To proper diff. of lat. —	232	—	2.36548
So is radius —	90 00	—	10.00000
To the distance —	392	—	2.59305

Here A represents Flamborough-Head, B, the Naze of Norway, the line AB the true distance, 278 miles, the angle CAB 33d. 22m. the course from the meridian, and in this chart the degrees of latitude are equal divisions, and easily represented, but the degrees of longitude, if they are inserted here, would be curved lines, and hard to project; nor is it needful, seeing upon this chart you need not regard the longitude as you go along, but only the course, and distance upon each course, according to the rules laid down in the second question of Traverse Sailing Geometrical. Fig. 10.

Having thus shewed how to make the several charts, I shall shew the use of them, when I come to give some examples of keeping a journal, in which I shall instance in the same voyage for which these charts are projected, and shall shew the learner how to prick off every day's work upon each chart, of which hereafter.

SECT. IV.

How to take an observation.

THE most usual and easy way to take an observation by the sun, is with a quadrant, commonly called Davis's quadrant, consisting of two arches, in some a 30 arch, and a 60 arch; but more commonly of late, an arch of 25 degrees, and another of 65; but the way of using them is all one and the same; for by these quadrants you do not so readily find the sun's altitude, but the complement of the sun's altitude, commonly (and properly) called the sun's zenith distance, being

ing the ſun's diſtance from the zenith, or point right over our head, which is eaſily found by one of the quadrants; for having fitted your vanes ſo, as that when you have the horizon right through the ſight vane and horizon vane, the ſhadow may at the ſame time fall directly from the top of the ſhadow vane to the top of the ſlit (which is the middle) of the horizon vane, ſtill removing the ſight vane downwards, as you obſerve the ſun to riſe, till you find that the ſun is upon the meridian, and then you have done your obſervation for that day. This done, obſerve what number or figure you have upon the 60 (or 65) arch, juſt under the upper edge of the ſhadow vane, (which ſhould always be placed upon an even 10 degrees, to ſave trouble in the addition) and alſo obſerve what degrees and minute you have upon the 30 (or 25) arch, juſt under the middle of the ſight vane, even with the line or ſtroke that goes from the hole along the middle of the vane; and theſe two numbers added together, the ſun is always the zenith diſtance, which is to be uſed as in the following directions for working an obſervation

How to work an obſervation.

THERE are but four caſes, or varieties in working an obſervation, in whatſoever part of the world you be, or whether the ſun's declination be north or ſouth.

The firſt is, when the ſun is between the horizon and the equinoctial, and then the rule is, ſubtract the declination from the zenith diſtance, the remainder is the latitude of the place.

Demonſtration.

The latitude of the place is the diſtance between the equinoctial and the zenith of that place. The ſun's declination is the ſun's diſtance from the equinoctial: and the ſun's diſtance from the zenith of the place, is the zenith diſtance or complement of the ſun's altitude. Now if from ⊙ Z the zenith diſtance, you ſubtract ⊙ E, the ſun's declination, there remains E Z, the latitude of the place of obſervation

Fig. 11.

Example.

Suppoſe the ſun's zenith diſtance be Z ⊙ 76, and the ſun's declination ſouth E ⊙ 16, ſubtract ⊙ E the declination 16, from

from ⊙Z the zenith diſtance 76, there reſts EZ 60, the latitude required.

The ſecond variety is, when the ſun is between the equinoctial and the zenith, and then the rule is, add the zenith diſtance to the ſun's declination, the ſum is the latitude of the place: for if to ⊙Z, the zenith diſtance, you add ⊙E, the ſun's declination, the ſum is E Z, the diſtance between the zenith and the equinoctial, which is the latitude required.

Example.

Suppoſe the ſun's zenith diſtance ⊙ Z 35, the ſun's declination north E ⊙ 10, if to ⊙ Z 35 the ſun's zenith diſtance, you add E⊙ 10 the ſun's declination, the ſum muſt needs be EZ 45, the latitude required. Fig. 11.

The third variety is when the ſun is between the zenith and the elevated pole, then the rule is ſubtract the zenith diſtance from declination, the remainder is the latitude of the place.

Example.

Suppoſe the ſun's declination be E ⊙ 20, and the zenith diſtance Z ⊙ 10; ſubtract the zenith diſtance Z ⊙ 10, from the ſun's declination E⊙ 20, there reſts EZ 10, the latitude required. Fig. 59.

The fourth variety is when the ſun is between the elevated pole and the horizon, and then the rule is, ſubtract the ſun's complement of declination from the zenith diſtance, the remainder is the complement of latitude.

Example.

Suppoſe the ſun's declination be 22, (its complement is 68) the zenith diſtance 85, then from zenith diſtance ⊙ Z 85, ſubtract the complement of declination ⊙ P 68, the remainder Z P 17, is the complement of latitude, which ſubtracted from 90, leaves 73, the latitude required. Fig 12.

But becauſe 'tis ſeldom that any ſail ſo far north or ſouth, as that they can conveniently take a backward obſervation by the ſun, under the elevated pole, in this caſe, it may be done by a forward obſervation, and work with the ſun's altitude or height above

above the horizon, and then the rule is, add the ſun's altitude to the complement of declination, the ſum is the latitude; thus if in the laſt example, you add the ſun's altitude, O ⊙ 5, to the complement of declination ⊙ P 68, the ſum O P 73, is the height of the pole above the horizon, which is the latitude of the place.

This ſame operation will hold in taking an obſervation by a ſtar, when under the elevated pole, becauſe both here, and in all other caſes in obſerving by the ſtars, we are obliged to take the obſervation forward, becauſe a ſtar caſts no light ſufficient for a backward obſervation, and then, inſtead of the zenith diſtance, work with the altitude.

In forward obſervations, whether by ſun or ſtars, there are alſo varieties, as in a backward obſervation, which I ſhall only ſpeak to, the demonſtrations being pretty evident from the foregoing figures.

The firſt caſe is, when the ſtar is between the equinoctial and the horizon, and then the rule is, add the altitude of the ſtar to its declination, the ſum is the complement of latitude, which ſubtracted from 90 leaves the latitude required.

Secondly, when the ſtar is between the equinoctial and the zenith, ſubtract the ſtar's declination from its altitude, the remainder is the complement of latitude.

Thirdly, when the ſtar is between the zenith and the elevated pole, then ſubtract the complement of declination, from the altitude, the remainder is the latitude.

The fourth variety is ſpoke to in the fourth variety before going; and ſo much ſhall ſerve for the working an obſervation; theſe rules, if well obſerved, being ſufficient for working obſervations in all latitudes, whether north or ſouth, and at all times of the year, as a little practice will make evident.

It is poſſible to take an obſervation by the moon: but there are ſo many things to be accounted for, as paralax, refraction, &c. and the moon ſeldom to be ſeen, but when ſome known ſtar may alſo be ſeen, and I having in this book inſerted a table of fixed ſtars, their declinations, &c. I ſhall refer the reader to it, the ſun and ſtars being ſufficient in all caſes for taking obſervations.

SECT.

SECT. V.

How to reckon tides.

Of the general motion of the tides, and how to know the time of high water at any known port, only by a sight of the moon at any time of the day or night.

THEY that would be able to give a good account of the tides, or of the time of high water or low water, at any port or harbour proposed, it is necessary, in order thereunto, that there be a right understanding of the original cause of the motion of the tides, or ebbing and flowing of the sea; a thing which hath been often in dispute among the learned, both mathematicians and philosophers, whose different sentiments have rendered the things as dubious as when they first began with it; some ascribing the fluctation of the sea to the swift motion of the earth, according to the Copernican system, and that the water being a fluid body, and not presently acquiring so swift an agitation as the earth itself, it must consequently be higher water upon one part of the globe than upon another, and this they illustrate thus: suppose a boat under sail, with fresh way, and a small quantity of water in the boat, it seems very plain, that the swift motion of the boat would make the water incline rather towards the stern of the boat; but if the boat, when sailing with that speed, should by coming ashore, or some other accident, meet with a sudden interruption, and at once stand still, the water still retaining in some measure its former motion, will presently run to the fore part of the boat, and by this they would some way or other demonstrate, that the motion of the tides depends upon the motion of the earth: but to use no other arguments for the confutation of this opinion, the absurdity hereof will appear in this, that if the motion of the earth were the original cause of the motion of the tide, then the tide must necessarily follow the motion of the earth, (or to our appearance the motion of the sun) and consequently it must always be high water at one place, at one and the same time of the day; but the contrary is so evident to all, that there needs no more to be said to disprove it.

Others say, the flowing of the tide is occasioned by a great confluence of water proceeding from the maelstream, called by some the navel of the sea, being (as it is reported) an eddy, or whirl-pool, under the west coast of Norway, or Finmark, from whence (it is said) during the six hours flood, the water issues violently out, and occasions the rising or flowing of the water in all the adjacent parts, and sinks with the same violence during the ebb; so that it is said, that during the flood, the heaviest metal will not sink; and during the ebb, the lightest substance, or the best of ships will not swim; but what reason they will give why this ebbing and flowing should be regulated and governed by the motion of the moon, I do not understand, unless this issue of water be supplied by some communication that it hath with the Eastern seas, by some passage under the main continent of Norway; but this being an uncertainty, we shall wave it as well as the opinion of a third sort, who affirm that God, who created all things, gave life to all his creatures: and that the ebbing and flowing of the sea is no more but the breathing of the earth, which seems to me a very odd fancy, and not worth inserting, had it not been in this collection of the various opinions of the learned upon this subject. I shall among the rest, deliver mine own opinion in the matter; and although I do not think my self able infallibly to give a definitive sentence in the case, yet I shall endeavour to prove it to be consistent with the observation and experience of our mariners, and shall answer what objections can easily be made against it.

It is evident to all that own the rotundity of the earth (a thing generally out of controversy amongst the learned) that there is a principal of gravitation towards the center of the earth, and that this attractive influence is diffused to all beings whatsoever within the orb thereof: and hence it is, that we that inhabit the earth find no such thing as an upper side and an under side of the earth, but in all parts of the superficies thereof we find a like natural tendency towards its center, as is evident by the experience of those that have sailed about the world, and yet in their so far different (if not diametrically opposite) places that they have sailed to, have found themselves and every particular thing to have the same pressing inclination towards the center of the earth, which seemed to them to be downwards, as well as it doth to us. Now if we grant the earth this strong principle of gravitation, inclination, or attraction towards its center, which reason and common experience prove, we have reason from hence to believe, that the other

bodies,

bodies, as the sun and moon, have the same principles of gravitation towards their centers, which may be proved by some reasons, which, to insert here, would be too great a digression from the present subject) which being granted, I suppose the ebbing and flowing of the sea, to be occasioned by the attraction of the sun and moon (especially the moon being a secondary planet, which moves far nearer the earth, and respects it for her center) the strength of which attraction, although it cannot have any influence upon the solid part of the earth, yet the water being a fluid substance, is more easily affected with this attracting power, and by virtue thereof (while the earth continues round) the water is gently sucked and drawn into an oval form, by reason of its inclining tendency towards those attractive bodies, thereby causing high-water where the ends of the oval is, and consequently low-water at the middle of the oval, as may be demonstrated thus: suppose two hoops made of any flexible substance, as wood, fine steel, &c. of equal dimensions, and laid directly one upon the other; and then if from opposite points the uppermost were extended into an oval form, it is evident, that as the extended part or end of the oval is drawn without the round hoop, the two sides, or middle of it, will be contracted and pulled within it; and still, as the transverse diameter of the oval were extended and augmented, the conjugate, or shortest diameter, will be contracted and diminished; which plainly demonstrates how the water, when by an attractive power it is drawn above its mean elevation, at the end of the oval, it must needs be depressed below its usual position at the two places a quarter distant from these two opposite points, which elevation and depression is the occasion of high and low water, which happens at (near) six hours distance, between high and low water, and confirms the truth hereof, which is also evident by the following reasons.

First, because the motion of the tides generally follows, and is governed by the motion of the moon; so that the moon being upon one and the same point of the compass, makes high water at any particular place, at one and the same time, (unless accelerated, or retarded, by winds, land-floods, or the like) by which it seems very probable, that the moon is the principal agent in this regular motion of the sea; and if so, then nothing more likely than that the influence of her attractive power drawing the flexible substance of water into an elliptical or oval form, as before asserted, is the cause thereof.

But secondly, it is observed by all, that the spring tides (*viz.* at the new and full moon) are greater than the neap-tides (which are at the first and last quarter) by which it seems evident, that although, as I said in the last paragraph, that the moon is the principal moving cause of the tides, yet the sun having also the like attracting power, hath an influence upon the water also, although not so great as that of the moon, because the moon is much nearer the earth, and is a secondary planet, respecting the earth for her center, and therefore, when the sun and moon are in conjunction (as at the new moon) or in opposition, (as at the full moon) then the tides are greatest; because the attractive influence of the sun is added to that of the moon, and both raise the water at one and the same place, making the spring tides. But at the quarters, *viz.* when the sun and moon are about 90 degrees, or a quarter of the zodiack distant, then the attractive influence of the sun rather impairs that of the moon; the one raising the water where the other depresses it; so that although, for reasons before given, the influence of the moon's attraction upon the water is greater than that of the sun, and therefore the tides follow the motion of the moon, and not of the sun, yet their contrary influence lessen the greater influence, *viz.* that of the moon; which is the cause of the neap-tides: and this also may be illustrated thus: suppose a hoop of steel, or any flexible metal, be fastened to any place, if a man with a rope fixed to one side thereof should pull with all his strength at the said rope, it would make the hoop decline into an elliptical or oval form; but if another man, though of an inferior strength, should fix a rope in the same place where the first was fixed, his strength added to the first would make the ring or hoop yet more elliptical, and would stretch out the traverse diameter thereof yet longer, in comparison of the conjugate. But if the first rope remain fixed as before, and the other, managed by inferior strength, be removed a quarter of the hoop's distance from the first, then, although the ellipsis will in some measure retain its oval form, inclining to the stronger attraction, yet the power of the contrary attraction will depress the other, and cause the hoop to retain a form at least nearer to a true circle, than as if the attraction were all in one place; and this plainly illustrates the different attractions, causing different tides, *viz.* when the attractive powers are united their influence is greater, causing the water to be more elliptical, thereby occasioning spring tides, at the new and full moons; but when the attractive

tive powers are ſeparated, as at the firſt and laſt quarter of the moon, the influence of the greater is not ſo apparent, which is at the neap-tides.

But my third reaſon is, becauſe we ſee that the ſpring tides at the equinoxes, *viz.* in March and September, are commonly higher tides than the ſpring tides at the ſolſtices, *viz.* in June and December: the ſun, and alſo the new and full moon, moving in or near the equinoctial, in a right aſpect to the earth; whereas their influence is ſomewhat impeded at the ſolſtices, by their more oblique poſition to the earth. All which ſeems plainly to prove, that as the tides are regulated and governed by the motion of the moon, ſo her attractive power, together with that of the ſun when joined with it, is the original cauſe thereof.

Now againſt what hath been ſaid, there ſeems two grand objections to ariſe; the firſt is, that if the tides be governed by the moon, and if her attraction be the cauſe thereof, her diurnal motion being from eaſt to weſt, it would follow that the flood-tides ſhould in all places ſet weſtward; but daily experience proves the contrary; for it ſets in ſome places ſouth, as upon the coaſt of England, and in ſome places north, as upon the coaſt of Holland; yea, and in ſome places eaſt, as in the Britiſh channel, which makes againſt my former aſſertion.

A ſecond objection is, that if the tides be cauſed by the moon's attraction, it ſhould be high water at all places, when the moon is upon the meridian of the place, or that a north and ſouth moon ſhould make full ſea in every place; but the contrary is evident by the tide tables, and by the experience of all ſailors.

In anſwer to the firſt, *viz.* that the flood-tide ſhould ſet weſtward in all places, (the anſwer to which will alſo partly imply an anſwer to the ſecond, *viz.* that it ſhould always be high water at any place, when the moon is upon the meridian of the place) I grant that if the tides be occaſioned as before aſſerted, then this regular motion of the ſea, from eaſt to weſt, muſt neceſſarily follow, if this terraqueous globe were equally envirioned with water, and that the aforeſaid motion of the ſea were not interrupted by the land; but it is evident, eſpecially where the ſea joins immediately upon the weſt of any main continent, that the flood cannot ſet weſtwards there, becauſe that would be right from the ſhore; as for example, ſuppoſe the whole land of Europe and Africa were all on the main continent; and ſuppoſe the north cape of Finmark, in about lat. 71 north, and the ſouth cape of Africa, in about lat. 34 ſouth, were both under one meridian, and that this main continent were terminat-

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ed on the west with a straight coast, lying under the same meridian, that the two extreme points, the north and south capes, lie under; now it is plain, that the tide cannot come from the eastward upon this west coast; but if the tide be caused by this westerly motion of the sea, according to the motion of the moon, it must set westwards, about the north and south parts of the said continent, and so proceed from the north cape southward, and from the south cape northward, along this west coast; and the truth of this seems evident also from our common experience; for we find, that the flood proceeds from the northward, along the coast of Norway, and there finding a passage between Scotland and Norway, marches along the east coast of England, and hence it is high water sooner in Scotland than in England, and sooner on the coast of the north part of England than on the south part; thus it is high water at Aberdeen in Scotland, 45 min. after moon's southing, but at Tinmouth-Bar, not till three hours after, and at the Spurn 5 hours and 15 min. and at Cromer 6 hours, and at Yarmouth-Pier 9 hours, and at Harwhich 10 hours 30 min. after the moon's southing; the tide, at the same time being rolling along the west coast of Scotland, and from thence to the west coast of Ireland, that passage between the north-east part of Ireland, and the south-west part of Scotland, being so narrow, that the tide finds little passage; and therefore the east coast of Ireland is supplied by a tide which sets southward along the west coast; and hence the tide flows eastward, along the south coast; and northward along the east coast thereof, as is evident by the time of high water observed in the tide-table; for upon the full and change days, it is high water at Seyn-Head at 10 hours 20 minutes, from thence in 6 hours it passes along the west coast, and butts in upon the south coast, so that at 4 hours 30 minutes it is high water at Kingsale, Cork and Waterford, and from thence in 45 minutes more, it passes over to Milford, Lundy, *&c.* and at the same time it slides northwards, along the east coast of Ireland; so that in 3 hours 45 m. it flows from Waterford to Dublin, and in 45 min. more to the Isle of Man, *&c.* Thus the general motion of the tide to the southward, having, as by a branch proceeding from thence, filled up all the vacancy between England and Ireland, it proceeds still to the southward, and upon the full and change days, it is high water at the land's end of England at 7 hours 30 min. and in its unwearied motion to the southward it finds a passage up the British channel, and 45 minutes after high water at the land's end it is high water at Portland, and in 3 hours 45 min. more, it

it is got up to the Isle of Wight, Southampton, and Portsmouth, being high water at the same time on the other side of the channel, upon the coast of France, about Guernsey and Jersey, and so proceeds slowly along the coast of France and Holland still to the northward, being supplied by a tide up the channel; and this (to follow it no further) may sufficiently prove, that the general and original motion of the tide westwards occasions its motion to the southward along the coast of Norway, and consequently all its compounded motions and branchings into the Irish sea, the channel, *&c.* And it is evident, that although the tide, if not interrupted, should be at the height where the moon is upon the meridian; yet it finding so many whirling motions to and fro between the lands, the moon, at the same time, keeping her straight and uninterrupted course to the westward, all the time that those irregular vacuities are filling up, it is plain, that the moon must needs be past far from the meridian before it can be high water at some of those places, and yet the tide occasioned as before asserted; which I think will sufficiently answer the two objections before mentioned, and prove this hypothesis to be very consistent with reason it self, and the experience of all observers.

Now if any body will still insist further upon what I hinted upon before, *viz.* that the tide is occasioned by a confluence of water arising at the mael-stream, or navel of the sea, and proceeding from thence, &c. and for confirmation thereof will alledge that they have seen and observed this regular rising and sinking of the water (before spoken of) at that place; I answer, I can easily approve of this opinion, without denying mine own hitherto asserted; for they are very easily reconcileable; since it is possible, and very probable, that this ebbing and flowing, at the meal-stream, may be occasioned by some subterraneous cavern, whereby this place hath some communication with the eastern seas, and is supplied from thence; which being granted, it will follow, that while the tide (whose general motion is westwards) is interrupted by the continent of Norway, &c. and thereby is forced to find a way about the north cape; yet by the way, finding this passage under ground, and the tide, by virtue of the moon's attraction, inclining that way, there may be supposed to be so much water conveyed that way as that obscure passage can contain, though far short of so much as to occasion that flowing and ebbing that is observed; and this being granted, it is evident, that this rising and falling at the meal-stream, must needs keep time with the motion of the moon, and of the rest of the tide;

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because it proceeds from the same original, and is a small branch thereof; and this we may see illustrated by our common rivers, whose natural motion, when interrupted by banks, or other impediments, causeth the main body of the water to find a passage some other way; yet if at the same time, any small holes be found in the said banks, there will always so much water pass thereby as the said holes can contain; tho' the main body of water is forced another way; hence, from what hath been said, it is plain, that this small flood and ebb observed at the meal-stream, must needs have the same regular motion with the rest of the tide, which I suppose has at first occasioned and since seemed to confirm that opinion that the tide proceeds only from thence.

To what has been said I shall only add, that this that I have here asserted seems yet to be further confirmed by our observations abroad; for it is observed, that there is a little or no tide at the Straits of Gibraltar, nor upon the coast of Guinea; nor can it be expected, according to this hypothesis; for if the tide comes from the northward, it may be supposed, that by that time it hath passed so far along, and having so many vacancies to fill up, as the German oceans, the Irish sea, the British channel, the Bay of Biscay, &c. its power must be very much impaired, if not totally exhausted, before it comes so far as the coast of Africa before-mentioned.

Now it may be questioned, what is the reason that there is little or no tide in the Baltick sea, seeing there are strong tides almost on every side of it, *viz.* upon the coast of Norway on the north of it, on the coast of Holland on the south, and on the coast of England on the west of it, &c.

I answer, it is hard to determine absolutely what is the cause thereof; but I shall lay down some conjectures, which may conduce very much that way; for if it is high water at the Naze and coast of Norway at the same time that it is high water upon the coast of Jutland southward from the Baltick sea, it must needs force a tide into the Baltick sea, as well as high water upon any coast forces a tide up the inland rivers there; but this cannot reasonably be expected, if we consider, that the tide along the coast of France, Holland, and Jutland, proceeds from the British channel, and comes from thence northwards, along the said coasts of Holland &c. but the tide upon the coast of Norway sets to the southward, as hath been largely proved, the two tides both terminating at the mouth of the Baltick sea; hence it is very probable, that it may be high water upon the coast

coast of Jutland, when it may perhaps be low water or some intermediate tide at the Naze, or south coast of Norway; and if so, it cannot force a tide into the Baltick sea, but rather a sucking current, or inclination of the sea from that place on one side of the mouth of the Baltick sea where it is high water, to that coast on the other side where it is low water; and hence it will necessarily follow, that this current must set sometimes one way, and sometimes another. And this may be assigned as a reason why many have found themselves deceived in their reckonings, when intending to make the Naze, or other lands thereabouts; and when they have imputed their mistake to a current setting towards that point of the compass towards which they have found themselves unexpectedly carried, thinking thereby to regulate their future reckonings, they have found themselves at another time under a quite contrary error, and hence have concluded that there was no current at all, but some other thing hath been the cause of their error; whereas, if the tides upon the coasts of Norway and Jutland, *viz.* on each side of the mouth of the Baltick sea, were carefully observed and determined, and the current allowed to run or set from the highest water to the lowest, (upon which of these coasts soever it were) and to be at a stand only when the water upon both the said coasts were of equal height (whether rising or falling) I question not but that the motion of this current might thereby be limited and determined, as well as the motion of the tides elsewhere, and due allowance might be given for the current there, as well as for the ebbs and floods in other places, to the great satisfaction and advantage of those that use the East-Country trade.

This motion of the tide thus granted, I shall next shew how to find the time of the moon's southing, and (with a little application) the time of high water by a sight of the moon, at any time of the day or night.

How to know the time of the moon's coming to the south, only by a sight of the moon, at any time of the day or night.

IT is commonly known, that the new moon being in conjunction with the sun, souths at noon, and the full moon being opposite to the sun, comes to the south at midnight; and at the quarters, when she is just half full, *viz.* to the line N. 6 S. which crosses the figure directly in the middle, then she is south at 6 o'clock, and if the light half Fig. 61.

be on the west side, N. W. S. and she half full, she souths at 6 in the evening, as at the first quarter; but if the light half be on the east side, N. E. S. she souths at 6 in the morning; which granted, the moon's coming to the south upon any other phasis; or at any intermediate age, may be easily gathered from the figure, observing this general rule; when you see the moon at any time of the day or night, observe how much of the moon is light, whether on the east or west side, and compare it as near as you can with the figure, considering to which line in the figure you suppose the light part will reach, and observe what number is upon that line, for that is the hour at which the moon will come to the meridian that day or night; as for example.

Suppose I observe the moon, and find her somewhat more than half light on the east side, so that comparing the moon with the figure, I suppose the light part to appear like the light part of the figure, then I observe to what number the light part reaches, and I observe it reaches to the number 5; and hence I conclude, that the moon comes to the south about 5 o'clock; and because the light part is on the east side, I conclude it is at 5 in the morning she will be upon the meridian.

Again, suppose I see her in the evening, and the light part on the west side, as near as I can compute, to be like the darker part of the figure, towards the right-hand, then observing how far the light part extends, I see it comes to the figure 5, and because the light part is on the west side, I conclude she will be south at 5 in the evening, &c.

And thus as you observe the moon two or three days after the change to appear in the west in the evening, with a very little light on the west side, which by computation may be supposed to come as far over the moon's body as the figure 3, I conclude she has been upon the south that afternoon about three o'clock, and the next night you will observe the light to increase, and come towards the figure 4, I conclude she was south that afternoon between 3 and 4, or near 4, and then perhaps 5 or 6 days after, I observe the light part increased beyond half the body of the moon, as far as the arch N. 8. S. I conclude from hence, that the moon is south about eight that night; and although this method is not sufficient to find the moon's southing exactly to a minute, yet it is of sufficient exactness for reckoning the tides, where a quarter of an hour, or half an hour, make no material error; it being generally impossible to predict the tides

to

to the absolute exactness of a minute, although you had the moon's southing exactly, because winds, or land floods, &c. may alter the tides, and few that have the charge of a ship will trust to the first or last scruple of the tide for going into an harbour, or coming out, but will endeavour, if possible, to have the best of the tide, and to be ready for it against it come, whether ebb or flood.

The moon's southing being thus found, the next thing is to shew how thereby to find the time of high water, at any known port; and for an help thereunto, I have inserted a tide table, in an alphabetical order, in which you need but find the name of the port, at which you would know the time of high water, and against it you have a number of hours and minutes, which added to the time of the moon's southing, gives the time of high-water at that place that day; as for example;

Suppose I were lying before Tinmouth bar, waiting for half flood to go in, I happen to see the moon in the morning, and I observe the east side of the moon to be light, like the light part of the figure before spoken of, *viz.* It is by computation so much above half the body of the moon, that the whole light part reacheth to the figure 5; and because the light is on the east-side, I conclude she is south at 5 in the morning, then I look in the tide-table, in the letter T, and find Tinmouth, and against it I find 3 hours 0 minutes, which added to 5, the time of the moon's southing, the sum, which is 8 hours 0 min. is the time of high water at Tinmouth bar; so that I find I may go in about 5, 6, or 7 o'clock, with the flood tide, according to the draught of water that my ship requires.

Now it is not necessary, that you should always have this book or figure about with you, for you may, with a very little practice, get the nature and reason of it imprinted in your memory, always remembring that the new moon being with the sun souths at noon, and full moon being opposite to the sun, souths at midnight. The moon in the first quarter is south at 6 in the evening, and at the last quarter is south at 6 in the morning. All the intermediate times of her age may be easily computed according to the figure, exact enough for finding the time of high water at any port mentioned in the tide-table.

If any will object, that what hath been said serves only for finding the time of high water, at places mentioned in the tide-table, but no where else; I answer, that by this way of finding the moon's southing, and consequently the time of high

water

water at any port mentioned in the table, together with a right apprehension of the general motion of the tides, as you have it sufficiently described and illustrated, in the beginning of this section, you may be able to give a very good account of the tide both at those places inserted in the table, and at those that are not, provided you know but upon what coast the places are, and how situate from some known place expressed in the table, and whether they are upon the sea-coast, or up some river, and the like; as for instance, suppose coming from the west of England, up the channel intending for Bulloigne, and not having a tide-table that hath the port of Bulloigne expressed in it, I am at a loss to know how the tide falls, (supposing it at new moon.) Now suppose in my tide-table, I find Diepe and Dunkirk (ports at each side of Bulloigne) and upon examination I find it is high water at Diepe, on the full and change days, at 9 hours 45 min. Again, I find it is high water at Dunkirk the same day at 12 o'clock; now I conclude that Bulloigne lying betwixt these two ports hath also high water between these two times, and not long after high water at Deipe, as, if you look in the table, you will find it is high water at 10 hours 30 min. at the full and change.

In like manner, if you observe the general motion of the tide to the southward, along the east coast of England, and to the eastward, up the channel, &c. you may, by knowing the time of high water at any port, very easily compute the flowing and ebbing of the tide at any adjacent port, and with allowance for deep bays, or inland rivers, you may very nearly determine the time of high water at any desired port.

But for variety and the universal satisfaction of all navigators, I shall insert another (though common) method of finding the moon's age and southing, by the epact, in order to which you must first find the golden number, which is thus done.

Add 1 to the year of our lord, and divide that sum by 19, the remainder is the golden number.

2. For the epact multiply the golden number by 11, and divide the product by 30, the remainder of that division is the epact for the year proposed.

3. For the moon's age add the epact, the day of the month, and the number of the months (as expressed below) together, and cast away 30 if the sum exceeds, the total if under 30, or the excess if above 30, is the moon's age.

4. For

4. For the moon's southing, multiply the moon's age by 4, and divide the product by 5, the quotient is the hour, and for every 1 that remains add 12 min. gives the time of the moon's southing.

The numbers for the months are
0 2 1 2 3 4 5 6 and 8
8 10 and 10 these are the numbers right.

That is, Jan. 0, Feb. 2, March 1, April 2, May 3, June 4, July 5, August 6, Sept. 8, Oct. 8, Novemb. 10, December 10.

Note, The epact is here supposed to change the first of January.

Example.

I desire to know the time of high water at Berwick the 16th day of October 1722.

First for the golden number.

The year	—	1722	19)1723)90
Add	—	1	13
Sum	—	1723	

The quotient 90 is of no use in this case; the remainder 13 is the golden number required.

To find the epact.

The golden number	—	13
Multiply by	—	11
		13
		13
The product 143 divide by		30)143(4
Remains the epact	—	23

Or divide the golden number (13) by 3, the remainder (1) multiply by 10, the product (10) add to the golden number (13), the sum (23) is the epact.

For the moon's age.

The epact	—	23
The number for October		8
The day of the month		16
Sum	—	47 from which abating 30, the

remainder

remainder 17 is the moon's age required, the moon changing the 29th of September, as may be seen by the table of the moon changing immediately following the tide-table.

For the moon's southing.

Multiply the moon's age 17 by 4, the product 68 divide by 5, the quotient is 13, and 3 remains, *viz.* 13 hours and 36 min. past noon, or 36 min. after 1 the next morning, to which add 1 hour 30 min. found against Berwick in the tide-table, the sum 3 hours 6 min. is the time of high water at Berwick, October 17, 1722, in the morning.

But because the spring tides do not shift so much as the neap tides, you may yet be more exact in using the table annexed.

The use of this table is very easy, I shall instance in the foregoing example.

Find the moon's age 17 under [moon's age] and against it in the column of [time] you have 1 hour 21 minutes, which added to 1 hour 30 minutes, the time found against Berwick in the tide-table, the sum 2 hours 51 minutes is the time of high water required, differing from the former by 15 minutes, and nearer the truth, because it allows for the differing shifting of the tides; but either way is exact enough for common use.

Moon's age.		Time. H.	M.
1	16	0	42
2	17	1	21
3	18	1	52
4	19	2	22
5	20	2	53
6	21	3	28
7	22	4	8
8	23	4	55
9	24	5	50
10	25	6	53
11	26	7	58
12	27	9	4
13	28	10	8
14	29	11	5
15	30	0	0

☞ *Note*, What is here said of the tides is meant as to their general motion; the half tides, quarter tides, and currents, being a thing that depends so much upon experience, that it is in vain to treat of them here.

A large

A large Tide-table after a New Method.

A	H.	M.
Aberdeen	0	45
Army	1	30
St. Andrews	2	15
Amsterdam	3	0
Armentiers	3	0
Abroth	3	0
Antwerp	5	15
Archangel	6	0
Abermorith	6	0
Amazons river in South America	6	0
Aldborough	9	45

B	H.	M.
Beach	0	0
Bajador in Barbary	0	0
Blacktail Beacon	0	15
Blackness	1	30
Bell Isle	1	30
Berwick	1	30
Bluet without	2	15
Britain South coast	3	0
Biscay coast	3	0
Bourdeaux river	3	0
Buchaness	3	0
Bona Esperance	3	0
Brest	3	45
Bass without	2	45
Bridlington	3	45
Bourdeaux river within	3	45
Brovage without	3	45
Baltimore	4	30
Bree Sound	4	30
Bremen	6	0
Blackney	6	0
Bristol	6	0
Bristol key	6	45
Bridgwater	7	30
Cape Blanco	9	45
Bulloigne	10	30
Race of Blanquet	12	0

C	H.	M.
Cape Cantin in Barbary	0	0
Calais without	1	30
Camfere	1	30
Coquet	3	0
Cork in Ireland	4	30
Cape Clear in Ireland	4	30
Caldy	5	15
Carnarvon Bay	5	15
Cromer	6	0
Caskets without	8	15
Cape Sierre-lion in Guiney	8	15
Chamberness	9	45
Cowes	10	30
Caen in the Foss	10	30
Calais Road	10	30
Calshot	11	15
Condado	12	0

D	H.	M.
Dunkirk	0	0
Dover Port	0	0
Port Desire in America	0	0
Downs		

	H.	M.
Downes	1	30
Dundee	2	15
Denby	2	15
Dort	3	0
Dunbar	4	30
Dungarvan	4	30
Dartmouth	5	15
St. David's Head	6	0
Dublin in Ireland	8	15
Dunnose	9	45
Diepe	9	45
Dunwich	9	45
Dungeness	9	45
Dover	10	30
E	**H.**	**M.**
Emden	0	0
Eider	0	0
Elve	0	0
Enchuysen	0	0
Edam	1	30
Edinburgh	4	30
Egmont	4	30
Egwater	7	30
Entrance of the Emes	7	30
F	**H.**	**M.**
Flanders coast	0	0
Flushing	0	45
Finmark coast	1	30
Founthey without	2	15
Flamborough Head	3	0
Fair Isle	3	0
Frith	4	30
Falmouth	4	30
Forn	5	15
Foy	5	15
Foulness	6	45
The Fly	7	30
Friesland coast	7	30

	H.	M.
Florida in Carolina	7	30
Foreland north and south	9	45
G	**H.**	**M.**
Gibralter road	0	0
Gravelling	0	0
Guernsey	0	45
Goree	1	30
Gravesend	1	30
Galicia	3	0
Gascoigne	3	0
Groyne	3	0
Gorend	11	15
H	**H.**	**M.**
Hever	0	0
Hern	0	0
Holy Island	1	30
Hartlepool	3	0
Huntcliff foot	3	45
Humber without	4	30
Holms	6	0
Hull	6	0
Hamburgh	6	0
Hague	8	15
Harlem	9	0
Havre de Grace	9	0
Harwich	10	30
St. Hellens	10	30
I	**H.**	**M.**
Jutland isles	0	0
Ireland W. coast	3	0
Ireland South coast	5	15
John de Luce	10	30
K	**H.**	**M.**
Kentish Knock	0	0
Killiars	3	0

Kingsale

	H.	M.
Kingsale in Ireland	4	30
Kilduyn	7	30
L	**H.**	**M.**
Lisbon	2	15
St. Lucas	2	15
London	3	0
Leith	4	30
Lawreneſs	4	30
Lynn without	5	15
Lundey	5	15
Lynn	6	0
Lanion	6	45
Landſend	7	30
Lizard	7	30
Lam Bay	8	15
Leoſtoffe	9	45
Lenow	9	45
M	**H.**	**M.**
Maze within	0	45
Malden	0	45
St. Mark	2	15
St. Matthew's point	3	45
Mount's Bay	4	30
Milford	5	15
Moonleſs	5	15
St. Maloes	5	15
Magnes Sound	8	15
Mecknel's Caſtle	8	15
Iſle of Man	9	0
Margate Road	11	15
N	**H.**	**M.**
Newport in the Iſle of Wight	0	0
Nore Weſt End	0	0
North C. Maggero	3	0
Nantz river without	3	0
Newcaſtle	5	15
St. Nicholas in Ruſſia	6	45
Needles	9	45
Normandy coaſt	10	30
Naze	11	15
O	**H.**	**M.**
Orkneys	3	0
Orwell	9	0
Orfordneſs	9	45
P	**H.**	**M.**
Portſmouth	0	0
Poictou South coaſt	3	0
Pens	3	0
Porthus	3	0
Portugal coaſt	3	0
Plymouth	6	0
St. Powls	6	0
Podeſemſk in Ruſſia	6	45
Portland	8	15
Peterport	8	15
Picardy coaſt	10	30
Q	**H.**	**M**
Queenborough	0	0
Quebeck in Canada	6	0
R	**H.**	**M.**
Rebdan	0	45
Rocheſter	0	55
Rumney	1	30
Ramkins	1	30
Robin Hood's bay	3	0
Rotterdam	3	0
Rovain	3	45
Rochel without	3	45
Roan river within	3	45
Ramſey	5	15

Z Rye

	H.	M.
Rye	11	15
Rhodes	11	15

S	H.	M.
Shoe	0	0
Sheerness	0	0
Sleeve	0	0
Southampton	0	0
Spits	0	0
Shotland	3	0
Scilly	3	45
Scarborough	3	45
Sound	3	45
Staples	3	45
Severn	4	30
Seven Isles	4	30
Stockton	5	15
Spurn	5	15
Salcomb	6	0
Start	6	45
Sedmouth	6	45
Selberg	9	0
Seven Cliffs	9	0
Shoreham	9	45
Seyn-Head	10	30
Senegal	10	30

T	H.	M.
Terveer within	0	45
Tenet	1	30
Terveer without	1	30
Tinmouth	3	0
Tees Mouth	3	0
Teneriff	3	0
Torbay	5	15
Texel	7	30
Tergon	9	45

U	H.	M
Urk	0	0
Use	3	0
Ushant without	6	0
St. Vallery	10	30

W	H.	M.
Isle of Wight	0	0
Winchelsea	0	45
Weilands	1	30
Whitby	3	0
Waterford in Ireland	4	30
Weymouth	6	0
Wells	6	0
Weymouth key	6	45
Wieringham	7	0
Winterton	9	0

Y	H.	M.
Youghall in Ireland	4	30
Yarmouth road	8	15
Yarmouth pier	9	0
Yarmouth town	9	45
Yarme	6	45

Z	H.	M.
Zealand coast	1	30
Zeiericke Zee	3	0

The

The use of this tide-table is the same as other tide-tables; for when you desire to know the time of high water at any place mentioned in the table, you need but look in the letter that the name of the place begins with: and there having found the place you want, see what hour and minute stands against it, which being added to the hour and minute of the moon's coming to south, the sum (abating twelve hours, if it exceeds) is the time of high water at the place proposed that day.——*Example*; I desire to know what time it will be high water at Harwich, June the 28th, 1770; I look in the letter H, and find Harwich, and against it 10—30, which added to the moon's southing that day, the sum is 14 30, from which cast away 12, the remainder is the time of high water: of which see more in the explanation of the following table of the moon's changing.

The use of the following table of the Moon's changing is so easy, that it needs little explanation; for find the year in the first column on the left-hand, and the month at the top, and in the common angle you have the day and hour of the moon's changing that month.

Note, N. stands for new moon; F. for full moon. *Example*. I desire to know the moon's changing in June 1770: find 1770 in the left-hand column, and against it, under June, you find 23.9 m. that is, the moon changes June 23 at 9 in the morning; and where you find two numbers against one year, and under one month, the moon changes twice that month; as against 1769, under August, you find $\left\{\begin{matrix} 1 : 11a. \\ 31 : 10m. \end{matrix}\right\}$ that is, the moon changes twice in August 1769, *viz.* the first day at 11 in the afternoon, and the thirty-first day at 10 morning, and so in the rest: from hence you may easily find the moon's age, and her southing, and consequently the time of high water at any port mentioned in the tide-table.

Example. I would know what time it was high water at Harwich, June 28, 1770, I look for the new moon next before, and I find it on June 23, and hence the moon on June 28 is 5 days old, which multiplied by 4, and the product 20 divided by 5, the quotient is 4 for the moon's southing, or 4 hours 00 minutes after noon, to which add 10h. 30m. the hours and minutes standing against Harwich in the tide-table, the sum is 14 hours 30 minutes, from which cast 12, remainder 2 hours 30 minutes, is the time of high water at Harwich required.

Years	January N and F D. H. ☽	February N and F D. H. ☽	March N and F D. H. ☽	April N and F D. H. ☽	May N and F D. H. ☽	June N and F D. H. ☽
1768	N 19. 6 A F 4. 6 M	N 18. 6 M F 2. 8 A	N 18. 4 A F 4. 6 M	N 17. 2 M F 2. 9 M	N [illegible] F 2. 2 M N 31. 3 A	N 14. 5 A F 30. 4 M
1769	N 8. 1 M F 22. 3 M	N 6. 6 A F 2. 5 A	N 8. 6 M F 22. 9 M	N 6. 5 A F 21. 1 M	N 6. 1 M F 20. 5 A	N 4. 8 M F 19. 9 M
1770	N 26. 11 A F 11. 5 A	N 25. 4 A F 11. 4 M	N 27. 6 M F 11. 5 A	N 25. 5 A F 10. 5 M	N 25. 1 M F 9. 6 A	N 23. 9 M F 8. 9 M
1771	N 15. 11 M F 30. 10 A	N 14. noon	N 16. 1 M F 1. 6 M F 30. 3 A	N 14. 8 A F 29. 2 M	N 14. 2 M F 28. 11 M	N 12. 3 A F 27. 1 M
1772	N 5. 9 M F 20. noon	N 3. 9 A F 18. 10 A	N 4. 10 M F 19. 6 M	N 2. 10 A F 17. 1 A	N 2. 11 M N 31. 11 A F 17. 1 M	N 30. noon F 15. 10 M
1773	N 22. 5 M F 8. 9 A	N 21. 6 A F 7. noon	N 23. 7 M F 9. 0 M	N 22. 8 A F 7. 9 M	N 21. 8 M F 6. 6 A	N 19. 9 A F 5. 0 M
1774	N 12. 2 A F 27. 8 A	N 11. 5 M F 26. 10 M	N 12. 4 A F 28. 1 M	N 11. 5 M F 26. 8 M	N 10. 5 A F 25. 4 A	N 9. 6 M F 24. 0 M
1775	N 1. 11 A N 31. noon F 16. 8 A	F 15. 2 A	N 2. 1 M N 31. 2 A F 17. 7 M	N 30. 3 M F 15. 9 A	N 29. 3 A F 15. 9 M	N 28. 4 M F 13. 5 A

Years	July N and F D. H. ☽	August N and F D. H. ☽	September N and F D. H. ☽	October N and F D. H. ☽	November N and F D. H. ☽	December N and F D. H. ☽
1768	N 14. 2 M F 29. 2 A	N 12. 1 A F 28. 1 M	N 11. 3 M F 26. 9 M	N 10. 8 A F 25. 6 A	N 9. 2 A F 24. 4 M	N 9. 8 M F 23. 3 A
1769	N 3. 3 A F 18. 10 A	N 1. 11 A N 31. 10 M F 17. 11 M	N 29. 10 A F 15. 11 A	N 29. 2 A F 15. 10 M	N 28. 8 M F 13. 8 A	N 28. 3 M F 13. 6 M
1770	N 22. 4 A F 8. 0 M	N 20. 11 A F 6. 3 A	N 19. 8 M F 5. 6 M	N 18. 8 A F 4. 8 A	N 17. 10 M F 3. 9 M	N 17. 3 M F 2. 9 A
1771	N 12. 4 M F 26. 4 A	N 10. 5 A F 25. 8 M	N 9. 5 M F 23. 11 A	N 8. 6 A F 23. 4 A	N 7. 7 M F 22. 7 M	N 5. 6 M F 21. 11 A
1772	N 30. 1 M F 14. 9 A	N 28. 2 A F 13. 10 M	N 27. 2 M F 11. 8 M	N 26. 3 A F 11. 7 A	N 25. 4 M F 10. 9 M	N 24. 5 A F 10. 4 M
1773	N 19. 9 M F 4. 7 M	N 17. 10 A F 2. 5 A	N 16. 11 M F 1. 4 M F 30. 7 A	N 15. 11 A F 30. 10 M	N 14. 1 A F 29. 5 M	N 14. 2 M F 29. 1 M
1774	N 8. 7 A F 23. 6 M	N 7. 8 M F 21. 3 A	N 5. 8 A F 20. 1 M	N 5. 9 M F 19. 2 A	N 3. 10 A F 18. 6 M	N 3. 11 M F 18. 1 M
1775	N 27. 5 A F 13. 1 M	N 26. 6 M F 12. 6 M	N 24. 6 A F 9. 5 A	N 24. 7 M F 9. 1 A	N 22. 8 M F 7. noon	N 22. 9 M F 7. 3 M

Note,

Note, If the moon be leſs than 15 days old, look for her age the day propoſed to find her ſouthing; but if more than 15 days old, look for her age the day before (or abate 1 from her age the day propoſed) and then work as before, becauſe when the moon is above 15 days old, ſhe comes to ſouth above 12 hours after noon, which may more properly be ca'led next morning, and conſequently if you abate 1 from her age found when above 16 days old, the ſouthing found from thence is properly her ſouthing for the morning of the day propoſed, *&c.*

SECT. VI. *How to keep a reckoning.*

HAVING thus learned to find the variation, and to work an obſervation, and alſo reckon your tides with other things neceſſary to be known, and having as maſter, mate, or pilot of a ſhip, taken your charge for any voyage, and having your log-line, glaſſes, and other things in readineſs, you muſt provide a log-board ruled as you ſee in the figure. Fig. 62.

Then having ſet ſail, and got from the ſhore, and out of the ſet of the tide, obſerve how the land bears from you that you intend to take your departure from; and alſo, as near as you can, compute the diſtance you are from it, and then that courſe and diſtance pricked off upon your chart gives the true place of your ſhip when you begin your reckoning.

This done, having ſettled your watches, and ordered a man to the helm for two hours, let him obſerve carefully what courſe he ſteers by the compaſs, or if he be ordered to ſteer upon any given courſe, let him take care to mind it, and at the end of two hours let the mate heav the log, having one attending him with the half-minute glaſs, let the mate over-haul off the line, (having firſt caſt the log with a few fakes of line into the ſea) till the red rag come to his hand, and at that inſtant cry *turn*; the man with the glaſs, juſt upon that word, as the red rag goes away, turning the glaſs, and watching diligently: when the half-minute glaſs is juſt out, the man that holds the glaſs cries *ſtop*; whereupon the mate ſtops, and hauls in the line, obſerving exactly how many knots, half knots, and fathoms are gone out, and ſets it down upon the log-board, againſt the hour at which the log was heaved, and thus proceed every two hours all the 24 hours, and then the log-board will be full the next day at noon.——Then having a log-book ruled every page, like the

the log-board, with the day of the month at the top, take off the log into your book, and rub out the chalks upon the board, so is the board ready for the next day. I shall instance in a voyage from a place in latitude 54 8 north, to another place in latitude 57 50 north, and difference of longitude 8 30 set sail August 24, at noon, and running that day as by the log following.

3. *Note*, Any 24 hours log, from noon to noon, is dated by the day upon which it ends, and not upon the day upon which it begins; then if we set sail August 24, that 24 hours log must be called August the 25th, &c.

The ship having run every two hours as you see in the log on the other side, add up all the knots together, the sum 47 being doubled) because you heave the log but every two hours) is 94, to which add the 4 half knots, which in this case are accounted as 4 whole knots, because they are also doubled: the sum 98 miles is the distance run that day.——The course is N. E. but because there is a point variation west, the true course is N. E. by N. therefore set down under the log——made good 98 miles N. E. by N.

Then find the traverse table, your northing and easting, for that course and distance, and set it in the blank space on the right-hand as you see done.

The northing 81 5 miles or minutes added to the latitude sailed from 54 deg. 8 min. the sum is the latitude come to 55d. 29m. (the 5 which is placed after the 81 being but a decimal, or half a mile, need not be regarded) which set also down as you see.

For the difference of longitude you may find it by the traverse table, the middle latitude being 55, its complement 35 being found, and under it in the column of departure, find the departure, or easting 54.4 or the nearest to; and against it, in the column of distance, you have 95 min, or 1d.—35 min. for the difference of longitude, made that day, all which set down as you see.

Now to find where your ship is, in the first or last of the charts before-mentioned, which are all made for this voyage: and first for the particular chart; set off 9 miles from A, upon a N. W. by W. line, it will reach to the point a, the place of the ship required; or take the difference of latitude made that day 81.5 in one pair of compasses; and the departure or easting 54.4 in another pair of compasses; then with one foot of each pair of compasses in A, and that in which you have the difference of latitude

H.	K.	½K	F.	Courſe	Winds	Auguſt 25, 1750.
2	3			N. E.	Weſt	Variation 1 point weſt Northing — 81. 5. Eaſting —— 54. 4. Lat. come to 55*d.* 29*m.* Diff. longitude 1 31.
4	4					
6	4	1				
8	5					
10	5					
12	5					
2	4	1				
4	4					
6	4					
8	3	1				
10	3	1				
12	3					

Made good 98 miles north eaſt by north.

latitude along the eaſt and weſt line AC, and that pair in which you have the departure along the north and ſouth line AB, the moveable points will fall in a as before.

To find where the ſhip is in the Mercator's chart, take the latitude in one pair of compaſſes thus; ſet one foot upon the line a d. in the latitude come to 55 29, which is at the point q, and

and extend the other to any parallel, as suppose the line 55 55; then after the same manner take the longitude in your compasses, running them parallel to any north and south line, the meeting of their moveable points, *viz.* at x, is the place of the ship required.—*Note*, the place of the ship at x, in the third chart is found by either of the two methods by which it is found in the first.

How to keep account of a ship's way upon a wind.

A Ship is said to sail upon a wind, when her tacks are abroad, and her yards sharp braced, and is commonly supposed to be within six points of the wind with lee-way, according to the sails she carries, *viz.*

All sails set	1	points	Try under mainsail only	5
A top-sail in	2		Under mizen only	6
Both top-sails in and a sea	3		Lye a hull, all sails furled	7
Try under main-sail and mizen	4			

According to these allowances of lee-way, I shall work the following examples; nevertheless, in practice, lee-way must be allowed according to judgment, for some ships make more lee-way than others, with the same sail set, &c.

This example, August 26, hath two courses, which must be reduced to one by the rules for working a traverse by the traverse table.——The first course is N. E. by the compass, but by the variation allowed, *viz.* one point west, it is N. E. by N. but the wind being N.N.W. *viz.* within six points of the course, we must allow one point lee-way from the wind, which brings it again to N.E.

For the distance, add up the first six number of knots, during which time she lay upon that course, the sum 21 doubled, and the two half knots added, makes in all 44 miles N.E. for the first course.

The second distance by the same rule, is 39 miles the course by the compass N. W. but a point variation west makes it N. W. by W. and a point lee-way which is also westerly, makes the course made good to be W. N. W. the distance 39 miles.

Course

Courſe	Diſt.	North	South	Eaſt	Weſt
N. E.	44	31-1		31-1	
W. N. W.	39	14-			36 0
		46-0			31 1
					4 9

By traverſe ſailing as performed by the table, you find the northing 46. 0. and the weſting 4.9, and by caſe the ſixth of plain ſailing, by the traverſe table, the diſtance made good is 46 miles north, 6 degrees weſt; all which ſet down as in the firſt day's work: then add this day's northing to the northing got before, the ſum 127 5 is the total northing. Alſo ſubtract this weſting 4 9 from the eaſting got before, the remainder 49 5 is the total eaſting, both which ſet down as you ſee; alſo by adding 46 minutes to the laſt day's latitude, the ſum 56 15 is the latitude come to.

The difference of longitude is 9 min. which becauſe it is weſt, it is to be ſubtracted from the longitude the day before, and the remainder 1d. 22m. is the longitude come to.

Now to find where the ſhip is, upon the firſt and laſt charts, take the total northing in one pair of compaſſes, and the total eaſting in another pair, and proceed as before from A, the place ſailed from, it ſhall produce the point e, for the place arrived at: alſo in the ſecond, which is a Mercator's chart, find the longitude and latitude come to by the method perſcribed in the firſt day's work, and their meeting or interſecting is at the point e, the place of the ſhip required.

Note, In the firſt and laſt charts you may ſet off one courſe and diſtance, by another, as in traverſe ſailing geometrical; but I ſhall not inſert that way, leſt it too much confuſe the draught.

H.

H.	K.	½K	F.	Course	Winds.
2	3			N. E.	NNW.
4	3	1			
6	4				
8	4				
10	3	1			
12	4				
2	3	1		N. W.	N.N.E
4	3	1			
6	3	1			
8	3	1			
10	3				
12	3				

August 26, 1750.

Variation	1 point west.
Northing —	45. 7.
Westing —	4. 9.
Total northing	127. 2.
Total easting	49. 5.
Latit. come to	66.15.
Diff. longitude	0 9.W.
Long. come to	1.31.

Made good 46 miles north, 6 degrees westerly.

How to correct a reckoning by an observation.

IN the following day's work, August 27, there is made good 116 miles; the course, with variation allowed, is N.E. by N. and the rest as you see found by the foregoing method.

It

It is needless to give any more examples of allowing for lee-way or variation, the rule being the same when lee-way is 4, 5, 6, or 7 points, as when it is but one point, only minding to allow as much as it is, and the right way. Thus if a ship lie north with wind at E.N.E. and 6 points lee-way, she makes her way good at W.N.W. *&c.*

My reckoning at noon, August 27, brings me into latitude 57, 71; but, by observation, which I must perfer before the dead reckoning, I find I am in latitude 57. 34. Now to correct the reckoning by an observation, observe this general rule.

If your difference of latitude be	more	than the depart. the fault is more likely to be in the	log. of dist.
	less		Co. or course.

The reason of the general rule above, is evident from the figure; for suppose a ship at A sail south easterly, Fig. 63. till by this reckoning he is at C, or in the latitude of the parallel BC, but by observation he is in the parallel of latitude D, E, F; now if we suppose his computed distance AC to be right, sweep the arch AC till it cut the parallel DF in F, and make AF equal to AC: now by this means the line AF is the line described by the ship's motion, whereas we thought it had been the line AC; but it is absurd to think that any should be so far mistaken in their course as to steer from A to F, when he thought he had been steering from A to C; and therefore we must impute the fault to the distance, supposing that the mistake lies there, and that when he thought he had steered from A to C, his reckoning was a-head of the ship, and that when he should have been at C he was only at E, the space E C being but a tolerable mistake in the whole distance A C.

But in a more easterly (or westerly) course, suppose a ship sail from A till his course and distance by dead rekoning is represented by the line AI, and the latitude come to by the parallel G I, but by observation he is in the parallel of latitude HLK; now if he were supposed to keep a right account of his course and the fault to be in the distance, we must continue the line A I till it cut the parallel H K, and allow him to be the whole distance I K mistaken in his account, which is absurd, and therefore impute the mistake to the course; and then with one foot of the compasses in A, with the extent A I describe the

arch

H.	K.	½K	F.	Courſe	Winds.
2	3	1		N. E.	Weſt.
4	4				
6	4	1			
8	5				
10	5				
12	5	1			
2	6				
4	6				
6	5	1			
8	4	1			
10	4	1			
12	4				

Aug. 27, 1750.

Variation 1 point weſt.	
Northing — —	96.4.
Eaſting —	64.4.
Total northing	223.6.
Total eaſting —	113.9.
Latitude come to	57.51.
Diff. long. eaſt	1.53.
Long. come to	3.25.
Lat. by obſerv.	57.34.
Tot. eaſt cor.	105.2.
Tot. north cor.	206.9.
Long. come to cor.	3 9

Made good 116 miles north eaſt by north

arch I L, and draw the diſtance A L equal to A I, and ſuppoſe that when he thought he had ſailed along the line AI, he had indeed ſailed along the line A L, the angle I A L, being a much more tolerable fault in the courſe, than the diſtance I K could be ſuppoſed to be in the diſtance.

Note, If you ſail in a current you may eaſily be groſly miſtaken, either in courſe or diſtance; but of that ſee more at the latter end of this book.

Now in this example the obſerved latitude Aug. 27. differs from the latitude by reckoning the quantity of 17 miles or minutes,

minutes, and becauſe the total northing is more than the total eaſting, I impute the fault to the diſtance by the log, and then it is corrected by this proportion.

As the total northing 223,6 to the total eaſting 113.9, ſo the error in the northing 17 to the error in the eaſting 8.7 neareſt.

```
 113.9
    17       223.6)1936.3(8 1475/2236
 ------              147.5
 797.3
 1139
 ------
 1936.3
```

or 8.7 miles neareſt, to be ſubtracted from the total eaſting 113.9 the remainder 105.2 is the total eaſting correct.

The reaſon of this proportion is evident from the diagram; for in the triangle ABC, as the total northing by reckoning AB, to the total eaſting by reckoning BC, ſo the error in the northing Eq, to the error in the eaſting qc; for the ſides of the triangle A B C, and Eqc, are proportional, by Euc. Lib. 6. Prob. 4.

Then to correct the longitude; as the proper difference between the latitude by reckoning, and the latitude by obſervation, to the meridional difference between the ſame two latitudes, ſo the error in departure to the error in longitude, that is, as 17 to 32, ſo 8.7 to the error in longitude.

```
  32       17)278(16
  8.7         108
 -----        ..6
  22.4
 256
 -----
 278.4
```

minutes, (rejecting the fraction, being but a fraction of a minute) to be ſubtracted from the longitude by dead reckoning, the remainder 19 35 is the true longitude corrected by obſervation.

But in caſe your courſe be far eaſterly or weſterly, and the obſerved latitude differs from that found by the dead reckoning, it is beſt to correct only the latitude, reducing it to the obſerved latitude, and not to meddle at all with the departure or difference of longitude, becauſe the error is too ſmall; as in the foregoing figure the true departure HL differs ſo little from the departure found by dead reckoning G I, that it is not worth while to correct it, unleſs you have ſome certain obſervation of longitude to correct it by.

When you have thus corrected your latitude, departure, and difference of longitude for this day at noon, as here

Aug.

Aug. 27, and proceed to the next day's work, add the next day's northing to the northing correct this day, to find the total northing next day, and not to the northing found by dead reckoning; and do the ſame alſo with the departure and difference of longitude, not regarding that found by reckoning; and ſo proceed as before; and when you get another obſervation to correct your reckoning by, add up only the northing and eaſting made good ſince the laſt obſervation, and not of the whole voyage, and ſo correct again according to this example.

Now for ſetting off that day's work, Aug. 27, upon each chart, the method is to be uſed that was before directed to, and the point Z in each chart, ſhall repreſent the place of the ſhip, Auguſt 27, at noon.

Now if you deſire to know the courſe and diſtance from the ſhip to the place propoſed, it may be done eaſily and exactly upon the two laſt charts, and chiefly upon the laſt of all the three; for in it you need but ſet one foot of the compaſſes in the point Z, where the ſhip is, and the other foot in the point B, the place bound for; that extent applied to the graduated line BD, accounting every degree 60 miles, and every ſmall diviſion 10 miles, gives the true diſtance required 53 miles.

In the ſecond chart, which is according to Mr. Wright's projection, commonly called Mercator's, if you uſe the method which you have there perſcribed, for finding the diſtance of any two places upon a Mercator's chart, geometrically, you will find it exactly agreeing with the former, *viz.* 53 miles.

For finding the courſe, the method is the ſame in both; for the rumbs are right lines, equally divided, at equal diſtances in both charts; therefore if your charts have the rumbs upon them, obſerve which rumb a line drawn from the ſhip to the port would be parallel to, for that is the courſe required; but if you would ſtill be more exact, you may find the true courſe and diſtance from the ſhip to the port, by caſe the ſixth of Mercator's ſailing trigonometrical thus, (having both latitudes and longitudes given.)

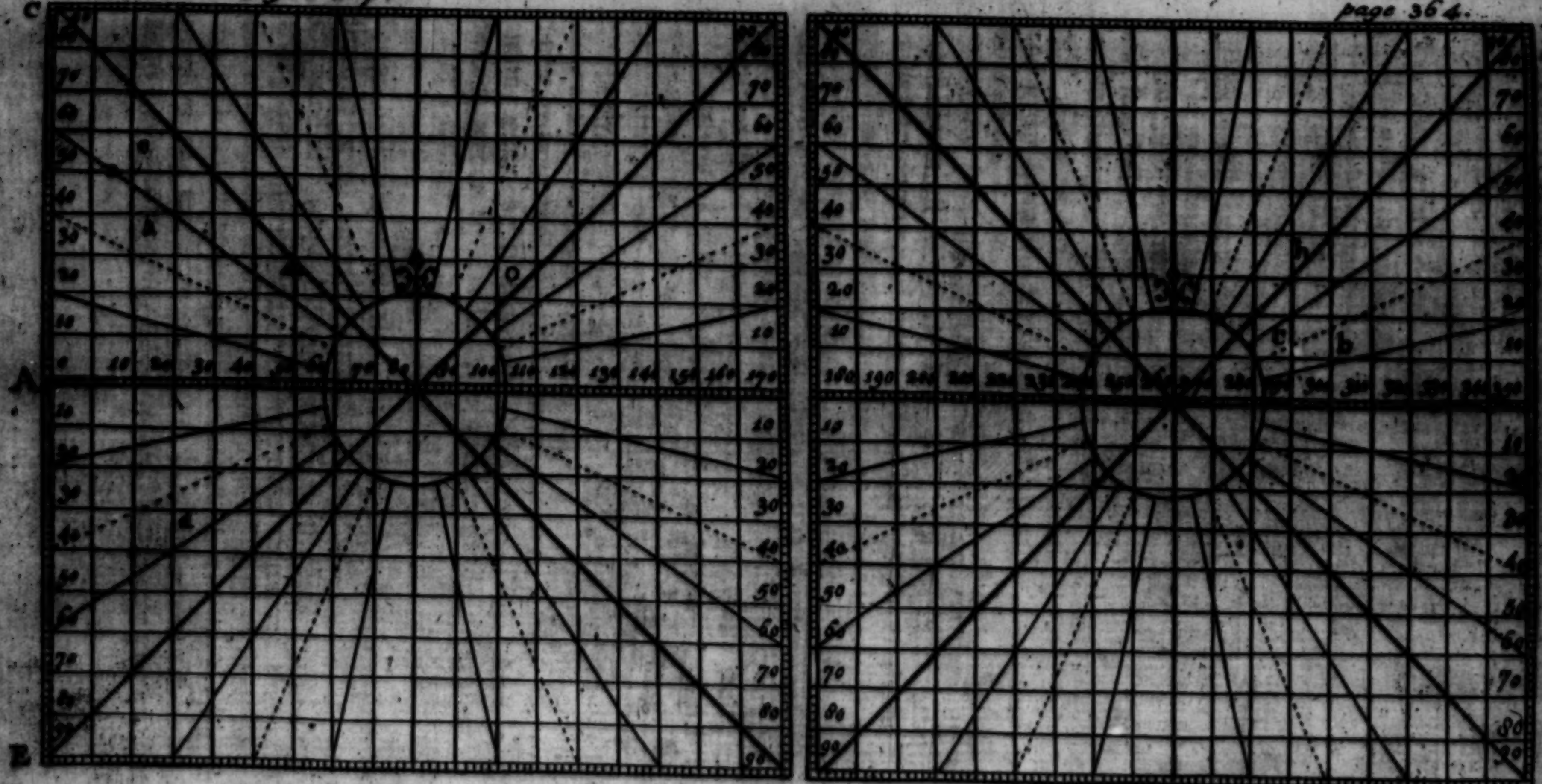
	Lat.	Long.
The ſhip when correct, by obſervation is in	57.34	3 9
The port bound for is in	57.50	8 30

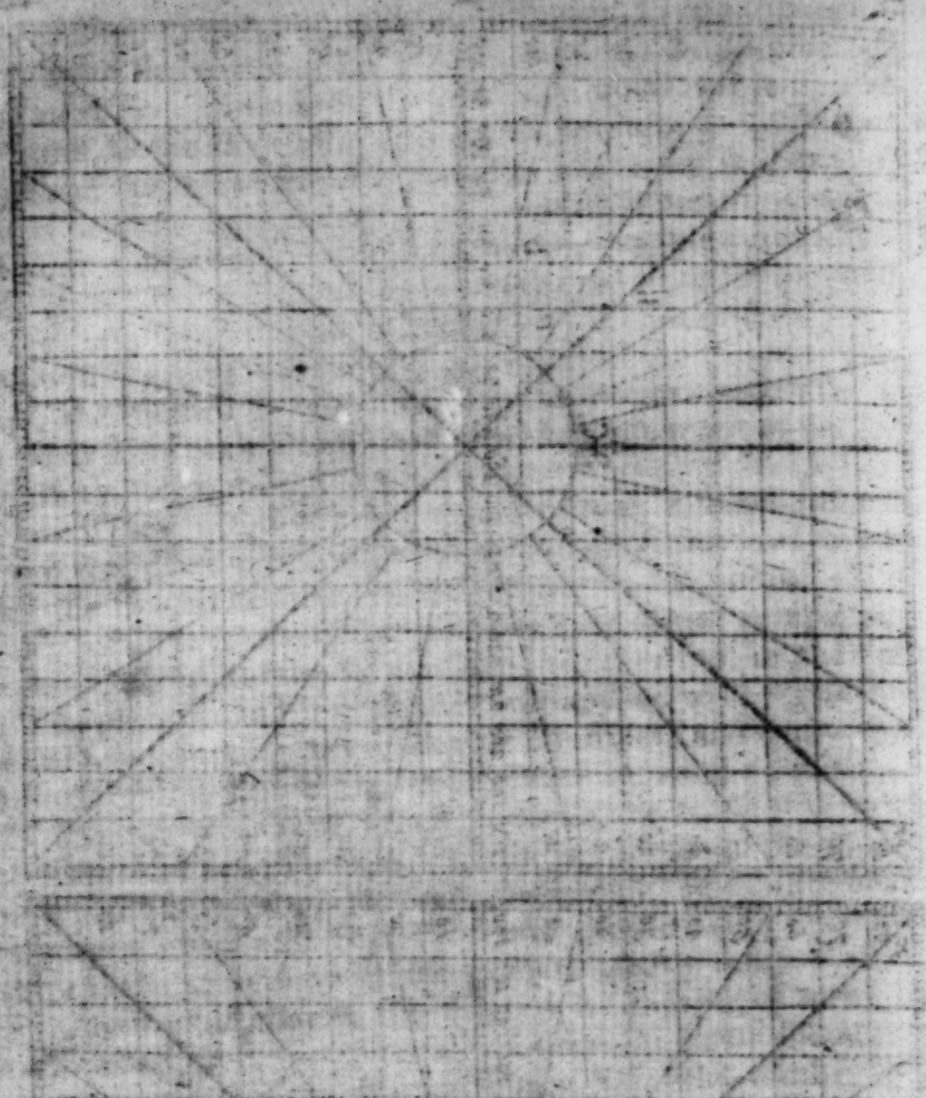
Proper diff. lat. 16. merid. diff. lat. 30.
Diff. long. 5.21 or 321.

As

Fig. 6 & 7.

page 364.





As merid. diff. of latitude	30	1.47712
To radius,		10.00000
So diff. of longitude	321	2.50650
To tang. of the courſe	84.40	11.02938

Then for the diſtance

As ſine comp. courſe—SC	84.40	896825
To proper diff. of latitude,	16	120412
So is radius,		10.00000
To the diſtance	172	2.23587

The courſe is north 84.40 eaſt, and the diſtance 172 miles.

But here we may ſee the intolerable error of the plain chart, the ſhip being at z, and the port bound for at the point ⊙, the extent between them being applied to the graduated line 16.36, and allowing 60 miles to each degree, gives a diſtance vaſtly too great from the ſhip at z to the port at ⊙, a moſt unſufferable error.

I know it is objected by ſome, that notwithſtanding what can be ſaid againſt the plain chart, it is ſtill the moſt uſeful and frequent among us, witneſs a great part of the charts and waggoners that are now extant, both in Dutch and Engliſh, and if the plain chart was ſo groſly falſe in ſo ſhort a voyage as between the two places before propoſed, it would ſeem that thoſe plain charts and waggoners ſhould not be ſo much encouraged, or being uſed ſhould not anſwer their end ſo generally well as they do.

I anſwer, I take it for granted that thoſe charts are not grounded upon that projection, that the degrees of longitude and latitude are every where equal, as thoſe commonly and properly called plain charts are, (for we find no ſuch thing as degrees of longitude upon them) but they are projected on the ſame ground that my third chart, before inſerted, is grounded upon, *viz.* the true courſe and diſtance from place to place is found, either by the latitude and longitude according to Mercator's ſailing, as I have directed in the projection of that chart, or elſe the courſe and diſtance from place to place is found by experience; thoſe that have ſailed there obſerving diligently what courſe (with all proper allowance for variation, &c.) and alſo what diſtance carried them from one place to another; and thus comparing their obſervations of that kind with the obſervations of others, and correcting their obſervations by their obſerved latitude, &c. And thus one obſerving in one place of the world, and another in another, and theſe obſervations being compared, and the moſt agreeable choſen out and collected,

collected, may probably have given rise to our large waggoners now extant; which, though in form of plain charts, yet in that case, must needs be true, and to be depended upon: for although the world is globular and not plain, yet it is evident, that what is once the course and distance between any two places, shall always be the Course and Distance between them. As for example, suppose after all allowance given for variation, lee-way, currents, &c. I find that a N. E. by E. course 240 miles, or 80 leagues, carries me from Buchaness to some known place on the coast of Norway; it is certain the same course and distance made good shall always do the same; and therefore if that course and distance was laid down upon any chart between these two places, I might safely depend upon that chart for my next going there.

Indeed it may be objected, who can tell how to allow so exactly for variation and lee-way, but especially for unkown currents, as to depend upon their reckoning for the true course and distance from place to place.

I answer, I agree to that; but yet when two, three, or more ships sail upon the same voyage, and find their accounts nearly to agree, this may make them somewhat more confident of their reckoning, and of the truth of it; and this I take to be a reason of the improvements that are yet daily made in charts and waggoners; these charts and tables of latitude and longitude which are of a later date, having doubtless attained nearer the truth by a greater confluence of observations, and thereby differing more or less from these of more ancient date, both in latitude, but chiefly in longitude of places; which difference we must impute to our attaining nearer to the truth, and to mistakes formerly committed, the places themselves remaining fixed and immoveable as to their situation upon the surface of the earth.

From what hath been said it will follow, that it is not necessary to dissuade any mariner from the use of those charts and waggoners now in print, but it is rather an encouragement to use them, and trust to them as very good helps; but let not this be an inducement to persons that have had plentiful experience of the truth and sufficiency of those charts and waggoners, presently to decline the use of them and fall to work to make charts of their own, and trust to them, if they have no other way for it but that hypothesis of supposing the degrees of latitude and longitude to be every where equal (which I have sufficiently proved is not the ground of the projection of those true

sea

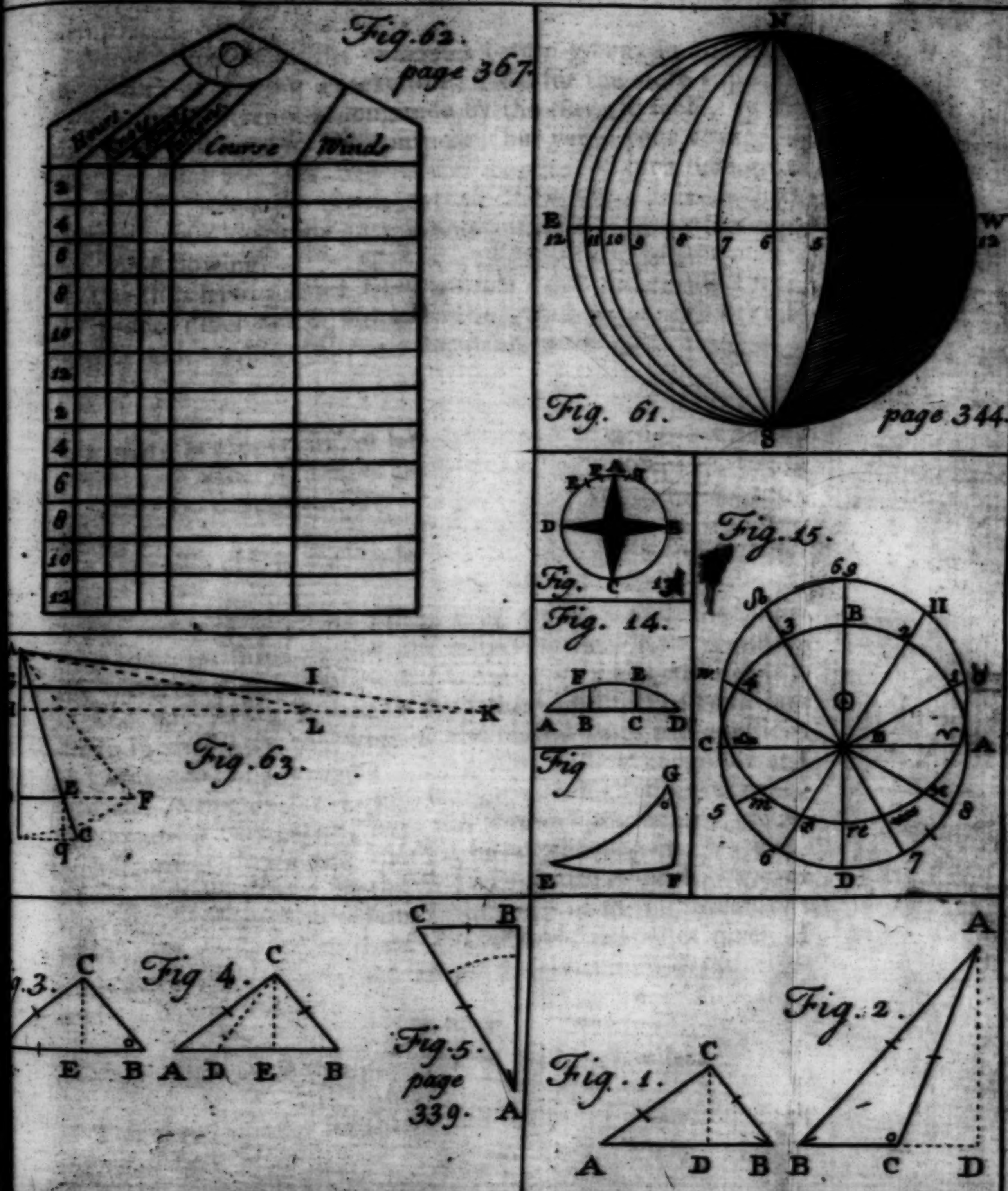


Fig.62.
page 367.
Hours
Course
Winds
2
4
6
8
10
12
2
4
6
8
10
12
N
E
W
12
11
10
9
8
7
6
5
12
S
Fig. 61.
page 344.
Fig. 13
Fig. 14.
F
E
A
B
C
D
Fig
G
E
F
Fig. 15.
B
C
A
D
I
K
L
Fig.63.
F
C
Fig.3.
C
E
B
Fig 4.
C
A
D
E
B
C
B
Fig.5
page
339.
A
A
Fig.2.
Fig.1.
C
A
D
B
B
C
D

sea-charts now in use) the absurd and intolerable falshood of which hypothesis aforesaid, I have sufficiently proved and demonstrated.

Note, Whereas in the examples before-going, in the three days work of keeping a reckoning, I did for the more expedition find my difference of longitude by the traverse table, by the rule there delivered for that purpose; but yet if your voyage be long, or near the pole, where the degrees of longitude grow much less, you may, if you distrust the truth of this method, examine your longitude once in three or four days, by this proposition following.

The ship having sailed from latitude 54.8, to latitude 57.34, the proper difference of latitude is 206, and the meridional difference of latitude is 368, and departure made good is 105.2.

		Co. Ar.
Therefore as proper diff. of lat.	206	7.68614
To merid. diff. of lat.	368	2.56584
So departure	105.2	2.02201
To diff. of longitude	188	2.27399

Difference of longitude 188 min. or 3 deg. 8 min. the longitude come to, differing but one minute from what is found by the traverse table, although that is found at three operations.

And now seeing I have in the former part of this book laid down methods for the working the several cases and questions in navigation, and keeping a reckoning both in longitude and latitude, not only by given numbers, which I have called Arithmetical Navigation, but also without any books, tables, or instruments, by a new method never yet known, nor published, I shall instance in the first day's work in both ways of operation, it being too tedious to instance in all the three day's works, especially seeing there are sufficient examples given of each method elsewhere; and first by the given numbers in arithmetical navigation.

The course that day is N. E. by N. 98 miles.

The given number for three points to find	diff. lat. is	—	8315
	departure is	—	5556

For difference of latitude.

$$\begin{array}{r} 98 \\ 83 \\ \hline 294 \\ 784 \\ \hline 81|34 \end{array}$$

81|34 diff. lat. 81.3.

It should be 81.5, but the error is only $\frac{2}{107}$, and is occasioned by omitting the two last figures of the given number.

For the departure.

$$\begin{array}{r} 98 \\ 555 \\ \hline 490 \\ 490 \\ 490 \\ \hline 54.390 \end{array}$$

the departure or east 54.39, or rather 54.4.

Difference of latitude 91.3, or 1 deg. 21 min. hence the latitude come to is 55 deg. 29 min.

For difference of longitude, the middle latitude is 45.48, but the next greater whole degree is 55, whose given number in the second table is 5735, but I shall only use the first two figures 57.

Departure with cyphers 57)5440(95
Given number, or divisors 310

$$\begin{array}{r} 57)5440(95 \\ 310 \\ \hline 25 \end{array}$$

The diff. of. long. 95m. or 1d. 35m. the remainder being but a fraction of a minute, we reject it.

The same day's work cast up by the new method.

The course 33.45 or $33\frac{3}{4}$, the distance 98 miles.

For the natural radius for $33\frac{3}{4}$ deg. by method the second, they that can work by cross multiplication, need not reduce the fraction to a decimal, but square it as follows.

$33\frac{3}{4}$

	$33\frac{3}{4}$	As 60.7 to 98 :: so $33\frac{3}{4}$ to depart.
	$33\frac{3}{4}$	$33\frac{3}{4}$
33 by 33 is —	1089	294
$\frac{3}{4}$ of 33 is —	$24\frac{3}{4}$	2943
The same again	$24\frac{3}{4}$	7 60.7)3307.0(54.4
$\frac{3}{4}$ of $\frac{3}{4}$ we reject		272.0
		3307 292.0
	$1138\frac{1}{2}$	
Mult. by	3	.492
		For diff. lat. by rule the third
	$3.415\frac{1}{2}$	Sum of the sides 1534
	57.3	Diff. of the sides 436
Nat. rad.	60.7	9144
		4572
		6096
		Product 6644.64(81.5 Square root of the product and difference of latitude required.
		64
		161)244
		161
		1831

For difference of longitude, the complement of middle latitude is 35, its natural radius is 61: therefore as 35 to 54.4 so 61 to difference of longitude.

54.4		
61	35)3318(94$\frac{28}{35}$	or 95 minutes, or 1 degree 35 minutes, the difference of longitude required.
	168	
54.4		
3264	28	
3318.4		

And thus you see the excellency and usefulness of this new method, by which, although by stress of weather or cruelty of enemies, you had lost all charts, books, tables and instruments, yet you may without any of them keep as just an account of your ship's way, both in longitude and latitude, as you can with them; as this and other examples inserted elsewhere in this book make manifest.

CHAP. III.

Containing several pleasant and useful questions.

SECT. I. *Of currents.*

IN sailing in a current it is very evident, that a ship doth not make her way good according to the course steered by the compass, and the distance run by the log, but being at the same time privately carried by a current, her true course and distance is compounded of the course and distance sailed, and of the course and motion of the current; therefore where both these are given, you must first lay down the course and motion of the current; and the course and distance from the place sailed from, to this last place thus found, is the true course and distance made good as in the first question following: a ship sails S. E. 100 miles from C to A, and a current sets in the same time west 30 miles; now if there was no current, the true course and distance of the ship would be represented by the line CA, and the point A should represent the place sailed to, but because a current sets west 30 miles, in the same time, I set off 30 miles W. from A to D, and the point D represents the place sailed to, and the line CD is the true course and distance made good; and hence in every question in currents, there is constituted a plain triangle, either right angled, or oblique, the angles of which some call the angles of reflection, deflection and incidence, as Mr. Norwood in his Seaman's Practice; but by the learned Mr. T. P. more properly the angle of force, the angle of submission, and the angle of chance: but I shall not trouble the learner's memory with these terms, but call them as indeed they are the course steered, or the course made good, &c. And therefore *note*, that by the course, or the course steered, I mean the course by the compass, and by the distance, I mean the distance by the log, but by course and distance made good, I mean the true course and distance of the ship, from the place sailed from, to the place come to, with allowance for the current, &c.

There are several cases and varieties in currents, but three are chiefly useful: the first is, when the course and distance is given, with the course and motion of the current also given, to find the course and distance made good. The second is, when

when the course and distance sailed, and course and distance made good is given, to find the course and motion of the current. The third is, when the course and distance made good, and course and motion of the current is given, to find the course and distance sailed, and this is of great use when the bearing and distance of two ports or islands are given, and the course and motion of a current between them is also given, to find how much to lay your ship to the windward of her true course, that so the set of the current with that course steered may just bring her to the proposed port.

CASE I. *Course and distance sailed, and course and motion of the current given, to find the course and distance made good.*

Geometrical construction,

A ship sails S.E. 100 miles in 24 hours in a current that sets west 30 miles in the same time, I demand what is the true course and distance made good in 24 hours time. With the course south east, and distance 100 lay it down as in plain sailing geometrical, and then it will appear as in the triangle A B C, and the ship should be at A; but because the current sets 30 miles west in the same time, set off 30 miles from A to D, because from A to D is west; then is the true place of the ship at D; therefore draw the line C D, then is the triangle CBD the true projection of the question, with allowance for the current, in which the angle BCD 29.56. is the true course made good, the hypotenuse CD 81.6. the distance, the leg CB 70.7 is the difference of latitude, and BD 40.7. is the departure, as may be found by measuring them geometrically.

Fig. 64.

Arithmetical calculation.

By case the first of plain sailing.

As radius	90.0	10.00000
To the distance	10.0	2.00000
So sine comp. course	4.50	9.84948
To the difference of latitude	70.7	1.84948

The departure is also 70.7 equal to the difference of latitude, because the course is south east, *viz.* at an angle of 45 degrees.

 But

But because the current hath set her 30 miles west in the same time, therefore subtract 30 from the departure found 70.7, there remains 40.7, the true departure with allowance for the current.

Then you have the true difference of latitude and departure given to find her course and distance, by case the sixth of plain sailing.

As difference of latitude	70. 7	1.84948
To radius	90. 0	10.00000
So true departure	40. 7	1.60959
To tangent of the course	29.56	9.76011

Then for the distance.

As sine of the course	29.56	9.69809
To the departure	40. 7	1.60959
So is radius	90. 0	10.00000
To the distance made good	81. 6	1.91150

Or the distance may be found thus, by case the fourth of oblique plain triangles.

In the oblique triangle BCD there is given the side BC 100 and the side DC 30, and the angle between 45 degrees: then by case the fourth of oblique plain triangle.

		Co. Ar.
As the sum of the sides	130	7.88606
To the difference of the sides	70	7.84509
So the tang. of half the sum of the unknown angles	67. 30	10.38277
To the tang. of half their difference	52. 26	10.11392

Hence the angle BDC is 119.56. and the angle DBC is 15.4.

Then for the side BD, which is the true distance made good.

As sine of DBC	15d. 4m. co. ar.	0.58513
To the side DC	50	1.47712
So is the sine of BCD	45 0	9.84948
To the side BD 81.6 the distance required		11.61173

But

But suppose the current had set upon an oblique course, and not due east, west, north, or south, the operation had been more difficult: as for example,

A ship sails S. E. 100 *miles a day, in a current that sets N.N.W.* 30 *miles a day; I demand the course, distance, difference of latitude and departure made good in one day.*

Geometrical construction.

Lay down the triangle A B C, as in the foregoing question, with the course S. E. *viz.* an angle of 45 degrees, the distance 100, the difference of latitude 70,7. and the departure the same as found before; then should the ship be at A; but because the current in that time hath set the ship 30 miles N.N.W. therefore set off 30 miles from N.N.W. from A to d, which may be done by the rule laid down in traverse sailing geometrical; for seeing the line CA is S.E. from C to A, it must needs be north west from A to C; and then seeing the currents sets N.N.W. which is two points to the northward of north west; therefore with the chord of 60, and one foot in A, draw the arch g d, upon which set off two points from g to d, and draw A d, which is a N.N.W. line, upon which set off 30 (the current's race) from A to d, and then is the true place of the ship at d, her true distance, C d 73.2 miles, her difference of latitude c q 43.0 miles, and her departure q d 59.2 miles, and the arch k h measures the angle at C 54d. om. the course required. Fig. 65.

Arithmetical calculation.

In the triangle ASD right-angled at S, you have given the hypotenuse A d 30, and the angle at A 67.30 (because A d is a N.N.W. line) to find AS and S d by case the first of right-angled plain triangles.

As radius	90 00—	10.00000
To the hypotenuse A d	30—	1.47712
So is the sine of the angle at A	67 30—	9.96561
To the leg S d	27 7—	11.44273

As radius	90 0—10.00000
To the hypotenuſe A d	30— 1.47712
So is the ſine of the angle at d	22 30—9.58284
To the leg AS	11 5—11.05996

The leg S d 27.7 equal to q B, ſubtracted from the whole difference of latitude CB 70.7, leaves C q the true difference of latitude 43.0; and the leg SA 11.5, ſubtracted from the whole departure 70.7, leaves 59.2, the true departure; by which you may find the true courſe and diſtance by caſe the ſixth of plain ſailing.

As difference of latitude	43 0— 1.63346
To radius	90 0—10.00000
So is departure	59 2— 1.77232
To the tang. of the courſe	54 0—10.13886

As ſine com. courſe SC	54 0— 9.76921
To the difference of latitude	43 3— 1.63346
So is radius	90 0—10.00000
To the diſtance	73 2— 1.86425

The true courſe is 54 degrees from the ſouth eaſtward, or ſouth eaſt near three quarters eaſt, and the diſtance is 73.2 miles.

CASE II. *Courſe and diſtance ſailed, and courſe and diſtance made good, given, to find the courſe and motion of the current.*

A ſhip ſails (by the compaſs) S. by E. 36 miles, and then arrives at a place which is known to bear from the place ſailed from S.E. by S. 54 miles, (having been deceived by a unknown current) I demand which way the current ſets, and how faſt, ſuppoſing the ſhip to ſail by the log 4 miles an hour.

Geometrical conſtruction.

Fig. 66. In this, and all other caſes of currents, as well as plain ſailing, traverſe, &c. draw the north and ſouth line AB, and ſet off the courſe ſteered by S. E. and diſtance

distance 36 miles from A to C; then set off also the course and distance made good 54 miles S.E. by S. from A to D; then because by the course steered by the compass, and distance run by the log, the ship should have been at C, but is found at D, therefore I am sure there is some current hath set me in the same time from C to D, therefore draw the line CD for the set of the current, which measured will be found to be 25 miles. And the angle ACD accounted from the N. by W. point because the line CA is a N. by W. line, will be found to be 11 points from the N. by W. eastwards, *viz.* E.S.E. 0 deg. 9 min. southerly, for the true course of the current by the rule laid down in traverse sailing geometrical for laying down courses by distance of points.

Arithmetical calculation.

In the oblique triangle ACD, you have given the side AC 36 miles, and the side AD 54 miles, and the angle between them 2 points, or 22d. 30m. (being the distance between S. by E. and S.E. by S.) to find the angle ACD, and the side CD, by case the fourth of oblique plain triangles.

		Co. Ar.
As the sum of the given sides	90	8.04576
To their difference ———	18	1.25527
So tang. of ½ sum of unknown angles	78.45	10.70134
To tang. of ½ their difference ———	45. 9	10.00237

The half difference of the angles ———	45d. 9m.
Added to the half sum ———	78. 45
The sum is the angle ACD ———	123 54

which reduced to points of the compass, is 11 points, 0 deg. 9 min. and that accounted from N. by W. finds E.S.E. 0 deg. 9 min. southerly, for the true course of the current.

Then for the side CD the current's race in that time.

			Co. Ar.
As sine of the angle ACD	123d.	54m.	0.08092
To the side AD ———	54		1.73239
So is the sine of the angle CAD ———	22	30	9.58283
To the side CD required ———	25		1.39614

So

So that the current sets 25 miles E.S.E. 9 min. southerly, in the time that the ship sailed, by the log, 36 miles S. by E. and supposing the ship to sail 4 miles an hour, she should sail 36 miles in 9 hours, in which time the current sets 25 miles, therefore divide 25 by 9, the quotient $2\frac{7}{9}$ miles is the hourly motion of the current.

CASE III. Course and distance made good by the ship, and course and motion of the current given, to find the course and distance sailed: or, more properly thus, having the bearing and distance, between two ports or islands given, and having also the course and motion of a current that lies between them given, to find what course to steer by the compass, or how much to windward of your true course to steer, that so the compound motion of the ship may just set her to the desired port.

There are two islands A and B; the course from B to A is south 40 degrees, westerly 80 miles: the current sets east $2\frac{1}{2}$ miles an hour, a ship sails $4\frac{1}{2}$ an hour, I demand what course she must steer from B to A, and how far she must sail by the log before she arrives at A, the port desired.

Geometrical construction.

Fig. 67. Draw the N. and S. line BD, and set off the course and distance from B to A south 40 degrees west, 80 miles from B to A: then because the current sets east, draw the east and west line AC at pleasure, by the rule laid down in traverse sailing geometrical, then is the side AB 80 miles, and the angle BAC 130d. 00m. given, but you have no other side nor angle given in the oblique triangle ABC, but you have the proportion of the two sides CA and CB, for C represents the motion of the current $2\frac{1}{2}$ miles an hour, and B C represents the motion of the ship thro' the water $4\frac{1}{2}$ miles an hour: therefore find the angle ABC by case the second of oblique plain triangles.

As the side BC $4\frac{1}{2}$, or in decimals	4. 5	Co. Ar.	9.34679
To the angle BAC ————	130. 0		9.88425
So the side AC $2\frac{1}{2}$, or ——	2. 5		0.39794
To the sine of the angle ABC	25.11		9.62898

The angle ABC is 25d. 11m. therefore make the angle ABC 25.11, and draw the line BC to cut AC in C, and then is the projection

projection finished, and the angle ABC 25 11 added to the angle ABD 40d.—0m. the sum 65d—m, from the south westerly, or W.S.W. almost $\frac{1}{4}$ southerly, is the course that the ship must steer to gain the port with allowance for the current.

Then for the side BC, the distance sailed by the log, subtract the sum of the two angles A and B 155d.—11m. from 180d.—0m. the remainder 24.—49m. is the angle ACB. Then,——

As sine of the angle ACB	——	24.9	Co. Ar.	0.37705
To its opposite side BA	——	80	——	1.90309
So sine of the angle BAC	——	130—0		9.88425
To the side opposite BC	—	146	—	2.16439

The distance sailed by the log is 146 miles, and the rate of sailing is $4\frac{1}{2}$ miles an hour, therefore divide 146 by $4\frac{1}{2}$, the quotient $32\frac{4}{9}$ is the hours that the ship will be in sailing from B to A.

Now if you would prove the work, multiply $32\frac{4}{9}$ the hours the ship is in sailing by $2\frac{1}{2}$, the miles that the current sets in one hour, the quotient $18\frac{1}{9}$, is the miles that the current sets in that time, represented by the side AC, which you will also find to be true by the following canon.

As sine of BAC	——	130.0	Co. Ar.	0.11575
To side opposite BC	——	146	——	2.16439
So sine of ABC	——	25.11	——	9.62891
To side opposite AC	——	81.1	——	1.90905

Note, It is necessary in this case to know how fast the ship sails, for the faster she sails, the less she need lye to windward of her true course against the current.

Case IV, *or* Question IV.

There are other varieties in sailing in a current, some of which I shall instance for the learner's improvement and diversion.

A current sets 32 miles a day E. N. E. a ship sailing therein steers S. S. E. by the compass, and finds that in 24 hours she is 30 miles distant from the place sailed from; I demand upon what point she hath made her way good, and how far she hath sailed by the log?

Geome-

Geometrical construction.

Draw the N. and S. line AB, and set off the ship's course steered S. S. E. 22.30, and draw the line AC continued; then any where upon that line, as at C, draw an E. N. E. line (as the line DC) by the rule laid down in traverse sailing Geometrical to represent the set of the current, upon which set off 32 miles, the currents motion in 24 hours, from C to D, then at the nearest distance from D to the line AC, (which here happens to be the length of the line CD because CD is perpendicular to AC) draw the parallel h D, then with 70 miles (the distance made good) in your compasses, and one foot in A, describe the arch Bg continued, and where it cuts the parallel hD as in g, begin the line g E, drawing it parallel to the line DC: then is A g 70 miles the distance made good, E g 32 miles, the set of the current E.N.E. The line AE 62.3 miles, the distance sailed by the log, and the angle E A g 27d. 12m. added to the angle B A C 22d—30m, the sum 49d—42m. is the course made good from the south eastward, or the arch k m measured on the rumbs, gives S. E. 4 deg. 42 min. easterly. Fig. 68.

Arithmetical calculation.

In the triangle A E g you have given the distance made good A g 70 miles, and the motion of the current E g 32 miles, and the angle A E g (which happens here to be a right-angle) 90 deg. to find the angle E A g thus.

As side A g	———	70 —	1.84509
To angle opposite A E g	——	90 0 —	10.00000
So side E g	——— ——	32 —	1.50515
To angle opposite E a g	———	27.12	9.66006

The angle E A g 27d. 12m. added to the angle BAC 22.30 the sum 49 42 is the true course made good from the south eastwards, *viz.* S. E. 4d. 42m. easterly.

Then for the side AE the distance sailed by the log.

As

As sine A E g	——— ———	90d. 0m.	10.00000
To side opposite A g	———	70	1.84509
So sine A g E	———	62. 48	9.94910
To side opposite A E	———	62. 3	1.79414

The course made good is S. E. 4d. 42m. easterly, and the distance sailed by the log is 62.3 miles.

And if you would prove the work by inverting the question, and proposing it in the first case of current sailing, thus,

A ship sails S. S. E. 62.3 miles in a current that sets E. N. E. 32 miles, in the same time, you will find the answer produces 70 miles S. E. 4d. 42m. easterly, for the course and distance made good.

Note, Although in this case the triangle A E g is right-angled, because the current's race E. N. E. makes a right-angle with the ship's course S.S.E. yet in any other case it would have been an oblique triangle; but the rules both for projection and calculation would have been the same.

Question the fifth, A ship sails 72 miles a day by the log, in a current that sets east 12 miles a day, and then finds that she hath made her way good at south east, I desire what course she hath steered by the compass, and what distance she made good.

Geometrical construction.

Draw AB, and with an angle of 45 deg. the course made good, draw the line AC continued, then with 72 the distance sailed by the log sweep the arch B d; then any where upon the line AB as at B, make an east and west line, because the currents sets east; then take 12 miles in your compasses, the current's motion, and set it parallel to B C, and so as that it may just extend from the arch Bd to the line AC, and here from e to g, and draw the line e g, and it's done —or if you think this method too mechanical for laying down the line g e, you may do it thus: you foresee that in the triangle A e g when laid down, there will be given the side A e 72, and the angle opposite to it 45 deg. and the side e g 12, to find the angle e A g, thus, Fig. 69.

As

As side A e	72	Co. Ar.	8.14267
To sine of angle opposite A g e	45.0		9.84948
So side e g	12		1.07918
To sine of angle opposite g A e	6.46		9.07133

which added to the angle A g e 45 deg. the sum 51.46 subtracted from 180, leaves 128.14, the angle A e g, therefore having set off 72 from A, upon the line A e from A to e, at e draw the line e g, to make an angle of 128.14 with the line A e, this line if carefully done will just contain 12 such parts, whereof the line A e contains 72, by that time it is extended to cut the line A g.

Then for the side A g the distance made good.

As sine e A g	6.46	Co. Ar.	0.92867
To side e g	12.		1.07918
So sine of A e g	128.14		9.89514
To side A g the distance made good	80		1.90299

Therefore for the course steered, subtract the angle e A g 6.46 from the whole angle given b A g 45, the remainder 38.14 is the angle, b A e the course steered, and the side A g found to be 80 is the distance made good.

Note, In finding the sine of any angle above 90 degrees, you must subtract the angle (whose sine is required) from 180 deg. the sine of the remainder, is the sine of the angle required, as in the example above, where the sine of 128.14 is required, subtract 128.14 from 180, the remainder 51d. 46m. sought in the table of sines, the sine answering to it is 9.89514; which is also the sine of 128.14 which was required.

And thus much for plain sailing in a current; many more questions might be invented from other Data's, but I would study brevity, that the book may not be too chargeable to the buyer, supposing that by a right understanding these rules the ingenious will be able to project and answer any other case or question in that kind; and as for traverse sailing in a current, although I thought to have placed it in a section or chapter by itself, yet I find it altogether needless; for the courses being first all reduced to one, by the rules laid down in traverse sailing, the operation for allowing for known currents, or finding the

the course and motion of unknown currents, is the very same with the rules here laid down.

Of turning to windward in a current.

THIS may also be divided into several cases, of which I shall speak in order; but that which is chiefly useful is where the course and motion of the current is given, with the course and distance between the place sailed from, and the place bound for, and from what point the wind blows, and how near the wind the ship will make her way good (for these four things are commonly given or known) to find how long she must lie upon each tack to gain her port, supposing her rate of running, or miles sailed in an hour by the log, be also given or known.

Example. Question the first.

There are two islands A and B, A is distant from B 90 leagues due north: a current sets from A towards B south 2 miles an hour, a ship at A intending for B meets with the wind at south, gets her starboard tacks aboard, and makes her way good within 72 degrees of the wind, and sails four miles an hour by the log, I demand how long she must lie upon each tack, to gain her port, and what course she makes good.

Geometrical construction.

Draw AB representing the bearing and distance of the two islands, *viz.* N. 90 leagues upon, the middle of which erect the perpendicular d C, then draw the line AC to make an angle of 72 degrees with the line AB, and continue the line AC till it cut the perpendicular dC in C, and draw the line CB, so shall the isosceles triangle ABC represent the two islands, and the ship's way to them without any allowance for the current, the line AC representing the ship's way with her starboard tacks aboard 72 deg. from the wind, and the line CB her way, with her larboard tacks aboard to fetch the island; but because every hour while the ship sails four miles by the log, the current sets her two miles to the southward, therefore find how many hours the ship is in sailing from A to C by the log; in order to which you must find the side AC by dividing the isosceles triangle ABC into two right-angled triangles Fig. 70.

A d C

AdC and BdC, then in the triangle ADC you have given the leg Ad 45 (being half the whole line AB which is 90) and the angle dAC 72 deg. consequently the angle ACd 18 deg. to find the hypotenuse AC, by case the fourth, of right-angled plain triangles.

As sine of Acd	———	18d. 0m.	9.41998
To side opposite Ad	———	45	1.65221
So is radius AdC	———	90 0	10.00000
To hypotenuse AC	———	$145\frac{1}{3}$ —	2.16223

Hence AC i $145\frac{1}{3}$ leagues or 436 miles, which divided by 4 the miles sailed in one hour, the quotient 109 is the hours, in which the ship sails from A to C; but the current setting south two miles an hour, 'tis plain that in 109 hours it hath set south 218 miles, or $72\frac{2}{3}$ leagues; therefore draw the south line C g, because while she sailed by the log from A to C, the current hath set her from C to g, therefore draw the line Ag, which shall represent the true compound motion of the ship or course made good; but because she is to lie upon that tack, but only till she be got half way to the port sailed for, observe where the line Ag cuts the perpendicular d C as in e, and then is the angle dAe, 49d. 37m. the true course made good by reason of the current, and the line A e the true distance sailed upon the starboard tack, *viz.* 69.3 leagues, and eB the distance sailed upon the larboard tack being also 69.3 leagues. But to know how far she will have sailed by the log, by that time that she will be at e by the help of the current, draw e k parallel to g C, this parallel shall cut AC and Ag proportionably by Euclid. lib. 6. prop. 2. *viz.* as A g to A e, so AC to Ak, hence Ak measured will be found to be 55.5 leagues, or 166.5 miles sailed by the log, which is divided by four, the miles sailed by the log in one hour, gives $41\frac{1}{2}$ hours, the time to stand upon the starboard tack, and the same upon the larboard, to fall in with the island at B, &c.

Arithmetical calculation.

In the oblique triangle ACg, there is given the side AC 436 miles, and the side Cg 218 miles, and the angle included Acg 108d. 0m. to find the angle CAg, by case the fourth of oblique angled plain triangles.

As

As sum of the sides	654	Co. Ar.	7.18443
To diff. of the sides	218	—	2.33845
So tang. of ½ sum of unknown angles	36.0	—	9.86126
To tang. of half their difference	13.37	—	9.38414

The half difference 13d. 37m. subtracted from the half sum 36d. om. rests 22d. 23m. the angle C A g, which subtracted from the whole angle d A C 72d.—om. leaves the angle d A e 49d.—37m. the course made good.

Then for the true distance made good A e: In the triangle Ade you have given A d 45 leagues, and the angle d A e 49d. 37m. consequently the angle Aed 40d. 23m. to find Ae by case the second of right angled plain triangles.

As sine of A e d	40d. 23m.		9.81150
To side opposite A d	45	—	1.65221
So radius	90	0	10.00000
To hypotenuse A e	69.3	—	1.84071

Then for the distance sailed by the log Ak (while by the help of the current she is carried to e.)

In the triangle Ake, you have given Ae 69.3, and you have given all the three angles, *viz.* Ake equal to ACg 108d. om. and Aek equal to AgC equal dAE 49d. 37m. and kAe 22d. 23m. equal to gAC, to find the side Ak by case the first of oblique angled plain triangles.

As sine of A k e	108d. om.	Co. Ar.	0.02179
To side opposite A e	69.3	—	1.84071
So sine of A e k	49 37	—	9.88180
To side opposite A k	55.5	—	1.74430

The side Ak, the distance sailed by the log, is 55.5 leagues, or 166.5 miles, which divided by 4, the miles sailed in one hour by the log, the quotient 412 is the hours that she must lye upon the starboard tack, in which time she is carried by the help of the current from A to e, and then lying the same time upon the larboard tack, she will arrive at B, the desired port; so that in 83 hours, she performs the voyage of 90 leagues, although upon a wind by the help of the current, which,

 had

had there been no current, would have required 218 hours, or 9 days and 2 hours.

Question the second.

There are two islands distant 400 miles N. and S. from each other, suppose A and B, A being the northermost; a ship at A intending for B, meets with the wind at south, she gets her starboard tacks aboard, and makes her way good through the water, within 72 degrees of the wind, a current at the same time setting south 24 miles a day, she stood 4 days upon each tack, and then arrived at her port at B: I demand my course and distance made good upon each tack.

Fig. 73.

Geometrical construction.

Draw the line A B 400, and at an angle of 72 degrees, draw AD, and BD, to cut each other in D, and from that intersection let fall the perpendicular DC, which will fall upon the middle of the line A B, then is the projection finished without allowance for the current; but because in that four days that she had her starboard tacks aboard, the current had set her 96 miles, set off 96 from C to e and h, and draw h k and eg parallel to CD, and where these parallels cut the lines AD and BD, as at g and k, draw the line gk to cut the perpendicular CD in m, and then to the intersection at m, draw the lines Am and Bm, for these lines shall represent the true compound motion of the ship, or course and distance made good, *viz.* the angle CAm 57d. 49m. is the course made good from the meridian, and the line Am equal to m B is the true distance sailed upon each tack, *viz.* 372.6.

Arithmetical calculation.

In the triangle A e g right-angled at e, you have given the leg Ae 104, and the angle e A g 72d. consequently the angle A g e 18d. to find the hypotenuse A g.

As

As sine of A g e	——	18d. om.	9.48998
To side opposite A e	——	104 —	2.01703
So radius	——	90. 0	10.00000
To the hypotenuse A g	——	336. 5	2.52705

Then in the oblique triangle A g m, you have given the side A g 336.5 and the side g m 96, because equal to C e, and the angle included A g m 108d.—om. to find the side A m.

			Co. Ar.
As sum of the sides	——	432.5 —	7.36402
To difference of the sides	——	240.5 —	2.38111
So tang. of half sum of unknown angles		36.0 —	9.86126
To tang. of half their difference		22.0 —	9.60639

Hence the angle g A m is 14d. oom. which subtracted from the whole angle 72, leaves the course made good, C A m 58d. om. Then for the distance made good.

			Co. Ar.
As sine of G A m	——	14d. om —	0.61632
To side opposite g m	——	96 —	1.98227
So sine A g m	——	108. 0 —	9.97820
To side opposite A m	——	377. 4 —	2.57679

The distance made good upon each tack is 377.4 miles; the distance sailed by the log upon each tack is A g and B k 336.5, the course made good 58d. om. from the meridian.

Question the sixth.

A master of a ship having taken a freight from an island at A, to another island at B, and having his son aboard along with him to gain experience, he enquires of his father, whether there was not a current setting upon some point between the two islands; his father refusing to tell him, bid him observe well the dead reckoning outward bound, and also home, and see if he could not, by comparing them, find the true course and motion of the current: whereupon the captain, who knew very

well what way the current ſet, and how the iſlands bore from each other, cauſed them to ſteer away ſouth, and in running 270 miles upon that courſe, they arrived at B, and having done his buſineſs there, they ſteered north-weſt, and running 380 miles upon that courſe, they arrived at A. Now I demand, how the iſlands bear from each other, and how far diſtant; alſo which way the current ſets, and how faſt, ſuppoſing the ſhip ſailed always at the rate of five miles an hour by the log?

Geometrical conſtruction.

Draw the north and ſouth line AC 270 miles, the firſt courſe and diſtance; then becauſe her courſe home was north weſt to A, draw the line AD at an angle of 45 degrees from AC (becauſe if DA be north weſt, AD muſt be ſouth eaſt, and conſequently make an angle of 45 degrees with the line AC) and ſet off 380 from A to D, and draw the line CD which repreſents the motion of the current during the ſhip's ſailing from A to C and from D to A; for the finding of which you have given the ſide AC 270, and the ſide AD 380, and the contained angle 45 deg. to find the angle ACD by caſe the fourth, of oblique plain triangles.

Fig. 74.

As ſum of the ſides	650	Co. Ar.	7.18708
To difference of the ſides	110	—	2.04139
So tang. of $\frac{1}{2}$ ſum of unknown angles	67.30	—	10.38277
To tang. of $\frac{1}{2}$ their difference	22.13	—	9.61124

The half ſum added to the half difference, makes the bigger angle ACD 89.43.

Then for the ſide CD.

			Co. A.
As ſine of ACD	89.43	—	0.00001
To ſine oppoſite AD	380	—	2.57978
So ſine of CAD	45.0	—	9.84948
To ſide oppoſite CD	268.7	—	2.42927

The ſide CD 268.7 miles is the current's race during the whole voyage: now to find the bearing and diſtance of the iſlands, we ſee that the whole voyage, out and home, the ſhip

ship runs 650 miles, which at 5 miles an hour, requires 130 hours, in which the current sets 268.7 miles, but her voyage outward being but 270 miles, which at 5 miles an hour requires but 54 hours, therefore say by the rule of three, if in 130 hours the current sets 268.7 miles, how far will it set in 54 hours?

268.7		
54	11	
10748	1450	98(110$\frac{11}{13}$ fere.
13435	1333	0
14509.8	11	

The current's race while the ship sails by the log from A to C is 110$\frac{11}{13}$ almost, but for ease of working we may call it 110.8, which set upon the line CD from C to B, and draw AB which represents the true course and distance between the two islands, for the finding of which by calculation, you have given, in the triangle ABC, the side AC 270, and the side CB 110.8 and the contained angle ACB 89.43, to find the angle CAB, by case the fourth, of oblique plain triangles.

		Co. Ar.
As sum of sides	380.8	7.41932
To the difference of the sides	159.2	2.20194
So tang. of half sum unknown angles	45.8	10.00202
To tang. half their difference	22.47	9.62328

Hence the angle CAB is 22d. 21m. the true course from A to B south easterly, which is south south east 9 min. southerly.

Then for the side AB the true distance between the islands.

		Co. Ar.
As sine of CAB	22.21	0.41992
To side opposite CB	110.8	2.04454
So sine of ACB	89.43	9.99999
To side opposite AB	291.4	2.46445

The true distance between the two islands is 291.4 miles.

 The

The course of the current is the angle ACD, found by th first operation 89d. 43m. from the north easterly, which is east 17 minutes northerly, and as for the rate or motion of the current's running, it is found by dividing the whole of the current 268.7, by the whole number of hours that the ship was under sail 130, the quotient is the miles that the current sets in one hour, as appears by the operation.

$$130\left\{\begin{array}{l}00\\268.7\\130.3\end{array}\right\}\left\{\begin{array}{l}87\\2—\\1300\end{array}\right.$$

Hence in answer to what was demanded, the course from A to B is S. S. E. 0d—9m. southerly.——The distance 291.4 miles, the course of the current is east 0d. 17m. northerly, and its rate or motion is $2\frac{87}{1300}$ miles an hour.

Now if you would prove the truth of the operation you may easily do it, by inverting the question, and stating it in the first case of Current Sailing, thus;

A ship sails south 5 miles an hour in a current, that sets east 17 min northerly $2\frac{87}{1300}$ miles an hour, I demand the course and distance made good, and you will find it will produce S. S. E. 9 min. southerly for the course, and 291.4 miles for the distance; but I shall leave the operation for the reader's practice.

CHAP. IV.

A new and exact method for finding the longitude in any place of the world, any day at noon, when the sun can be seen without any regard to, or dependance upon the dead reckoning.

THE often attempted, but never accomplished work of finding the longitude by an observation, is a difficulty which hath hitherto proved insuperable, even to the best mathematicians in England, and elsewhere, although since the late act of parliament, many have exerted their utmost industry for the attaining of that end, some of whom have been so far from compleating their intended design, that they have, on the

the other hand, rather rendered themſelves and their works ridiculous, by publiſhing ſuch improper and improbable methods, as a certain artiſt (if he deſerves that name) by certain fixed ſtars choſen for each time of the year, &c.

Whereas it is evident, that any fixed ſtar ſhall come upon the meridian of any place, at (near) the ſame hour of the day, that the ſame ſtar ſhall come upon the meridian of London, although not at the ſame inſtant of time, but ſooner or later, 3, 4, 5, or 6 hours, &c. according as the place is more or leſs diſtant eaſt or weſt from the meridian of London: but if there be that difference in hours as to the time of a ſtar's coming upon theſe two different meridians, there is alſo the ſame difference in hours between the time of the day or night at London, and that under that meridian; a ſouth ſun in both places making 12 o'clock; and 'tis very evident that at the ſame time of the day or night, that the ſtar comes upon the meridian of London, it ſhall be the ſame time of the day or night under any other meridian, when the ſtar comes upon that meridian, excepting ſo much as the ſun's right aſcenſion is increaſed in the time of the ſun's paſſing from one meridian to the other, which will cauſe the ſtar to come ſo much ſooner upon a weſterly meridian than upon an eaſterly: but this being ſo little, being about 4 minutes of time in 24 hours, or 360 degrees of longitude, and but 1 minute of time in 90 degrees, it is imperceptible; and yet (that ſmall allowance excepted) there is no difference between the hour of any fixed ſtar's coming to the meridian of London, and the hour of the ſame ſtar's coming upon any other meridian, becauſe the ſun's motion makes the hours of the day, and the ſtar muſt needs come upon the meridian the ſame quantity of time after the ſun in both places. Indeed, if we could certainly know what time of the day or night it is at London, when the ſun or any known ſtar is upon the meridian of any other diſtant place, the longitude might be eaſily and exactly found; in order to which let the maſter provide a good glaſs, which may run exactly 24 hours, or rather a good watch, that hath been obſerved aſhore, to keep a true and equal motion, this watch ſet to the time of day when you depart from any known meridian, and kept going, will ſhew the difference of longitude, that you make whether eaſt or weſt; for example, if you ſail weſtwards, obſerve juſt when the ſun is upon the meridian, and ſee what hour and minute it is by your watch, (which if you ſail weſtward it will be paſt 12) for thoſe hours and minutes which the watch is paſt 12,

 when

when the sun is upon the meridian reduced to degrees and minutes of the equator, allowing 15 degrees to one hour, and one degree to every 4 minutes of time, and 15 minutes of longitude to one minute of time, shall shew the true difference of longitude.

Note, If you sail eastward, your watch will want something of 12 o'clock, when the sun is upon the meridian; because then you meet the sun, and have him upon your meridian before he comes upon the meridian of London; in this case observe how much your watch wants of 12 o'clock, and that reduced as before, gives your difference of longitude easterly; this in general is the method that I shall recommend to the world for this end.

But I know it will be presently objected, that this is no new thing, nor is it practicable at sea; for some that have attempted to keep some account of their longitude this way, have found themselves in an error, not finding the difference between the watch and the sun, when reduced as above, to give the difference of longitude, which they were (for some reasons) pretty confident they had made, and this error they impute to the watch, and hence have inferred, that a watch will not go so truly and regularly at sea as on shore, by reason of the salt moist air that impedes its motion or makes it uncertain, according to the variableness of the weather, and thereby renders this method for finding the longitude impracticable.

I answer, I do not believe at all that this error is to be imputed to the watch if carefully kept, which you may easily do, if you provide a little square or round box about four or five inches broad, and have it filled with fine cotton, taking part of the cotton out and putting the watch towards the middle of the box upon the cotton you leave in the box, and put the rest that you took out upon the watch, and shut the box, keeping it in some dry place, as in your cabbin, or upon some shelf near your bed: I question not but a good watch so kept would go as true at sea as ashore.

But I suppose the error which hath been observed, and which hath caused any to desist from making any attempt to find the longitude this way, is for want of a right understanding of the equation of time, without which it is impossible to keep a good watch right, or to suppose it to be so either at sea or ashore; for a good watch, (or clock) divides the time equally, but the sun by reason of some inequalities in his motion divides the time unequally; so that if the sun and a true watch be set together

gether at sometimes in the year, yet the watch will at other times differ 10, 12, yea sometimes 16 minutes from the time given by the sun, and yet no fault in the watch, and therefore it is very evident that if for finding the longitude you only observe the time of the day given by the watch, without regarding this equation, especially when the equation is great, as 15 or 16 minutes, you will be so much wrong in your account of longitude, as that 15 or 16 minutes reduced to the equator amounts to, *viz.* about 4 degrees of longitude, which is an intolerable error, and might be prevented by allowing for the equation of time.

For further illustration hereof, suppose you set your watch with the sun the 17th day of June, *N. S.* then the equation is nothing, being in London at the same time, and continuing there till the 3d day of Nov. you will find your watch to be got 16 minutes behind the sun, from hence (if you do not know to the contrary) you might by the foregoing rule conclude that you had altered your longitude 4 degrees easterly, but if to the time given by the watch, you add the equation 16 min. the sum is the true time of the day by the sun, and proving you to be in the same meridian that you were under, when you set your watch to the sun, the difference in time, and consequently the difference of longitude being nothing at all.

A Table

A Table of the Equation of Time, New-Stile.

	Jan.		Feb.		March.		April.		May.		June.	
	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.
	Watch too Fast.		Too Fast.		Too Fast.		Too Fast. / Too Slow.		Watch too Slow.		Watch Slow. / Too Fast.	
1	4	14	14	15	12	47	3	58	3	14	2	56
2	4	42	14	22	12	35	3	40	3	22	2	48
3	5	9	14	28	12	22	3	22	3	30	2	39
4	5	36	14	34	12	8	3	3	3	37	2	29
5	6	4	14	38	11	54	2	45	3	43	2	16
6	6	30	14	42	11	40	2	[illegible]	3	49	2	9
7	6	57	14	45	11	24	2	9	3	53	1	59
8	7	24	14	47	11	9	1	51	3	57	1	48
9	7	48	14	48	10	54	1	34	4	[illegible]	1	37
10	8	12	14	49	10	38	1	17	4	4	1	25
11	8	37	14	49	10	21	1	1	4	7	1	14
12	9	4	14	48	10	4	0	45	4	10	1	2
13	9	26	14	46	9	47	0	28	4	11	0	50
14	9	48	14	44	9	30	0	12	4	12	0	37
15	10	10	14	41	9	13	0	3	4	13	0	25
16	10	31	14	37	8	55	0	11	4	12	0	13
17	10	50	14	32	8	37	0	33	4	11	0	0
18	11	9	14	27	8	19	0	48	4	10	0	13
19	11	27	14	21	8	1	1	2	4	8	0	26
20	11	45	14	15	7	43	1	16	4	6	0	39
21	12	2	14	7	7	25	1	28	4	3	0	52
22	12	18	13	59	7	6	1	41	4	0	1	4
23	12	34	13	50	6	47	1	54	3	56	1	17
24	12	47	13	41	6	28	2	6	3	51	1	30
25	13	2	13	31	6	10	2	16	3	46	1	43
26	13	15	13	21	5	51	2	27	3	40	1	56
27	13	27	13	10	5	32	2	38	3	34	2	8
28	13	38	12	59	5	14	2	48	3	28	2	20
29	13	48			4	59	2	57	3	21	2	32
30	13	58			4	36	3	6	3	13	2	44
31	14	7			4	17			3	5		

A Table of the Equation of Time, New-Stile.

	July		*Aug.*		*Sept.*		*Octob.*		*Nov.*		*Dec.*	
	M.	S.	M.	S.	M.	S.	M.	S.	M	S	M.	S.
1	2	56	5	38	0	18	10	16	15	59	10	20
2	3	7	5	34	0	36	10	34	16	1	9	56
3	3	19	5	30	0	55 Too Slow.	10	52	16	0	9	32
4	3	30	5	26	1	14	11	10	15	59	9	8
5	3	41	5	20	1	34	11	28	15	57	8	43
6	3	51	5	14	1	53	11	45	15	54	8	17
7	4	1	5	8	2	12	12	2	15	51	7	51
8	4	11	5	2	2	32	12	18	15	47	7	25
9	4	21	4	52	2	52	12	33	15	41	6	59
10	4	22	4	46	3	13	12	49	15	35	6	32
11	4	37	4	37	3	33	13	4	15	29	6	3
12	4	45	4	28	3	53	13	18	15	21	5	35
13	4	53	4	18	4	14	13	32	15	13	5	6
14	5	0	4	8	4	34	13	56	15	3	4	38
15	5	7 Too Fast.	3	57	4	55	13	59	14	53	4	9
16	5	13	3	47	5	15	14	11	14	41	3	40 Too Slow.
17	5	18	3	37	5	36	14	23	14	29	3	10
18	5	24	3	27	5	56	14	34	14	17	2	40
19	5	29	3	10 Too Fast.	6	17	14	44	14	3	2	10
20	5	33	2	55	6	38	14	54 Too Slow.	13	49 Too Slow.	1	40
21	5	36	2	42	6	58 Too Slow.	15	4	13	34	1	11
22	5	39	2	27	7	19	15	13	13	17	0	41
23	5	42	2	13	7	39	15	22	13	0	0	11
24	5	44	1	58	7	59	15	28	12	34	0	19
25	5	45	1	42	8	12	15	34	12	24	0	49
26	5	46	1	26	8	38	15	40	12	5	1 —	19
27	5	46	1	9	8	58	15	45	11	45	1	49 Too Fast.
28	5	45	0	52	9	18	15	50	11	25	2	18
29	5	44	0	35	9	37	15	53	11	4	2	47
30	5	42	0	17	9	57	15	56	10	42	3	16
31	5	40	0 —	1			15	58			3	45

This equation of time is caused by an inequality of the sun's motion from west to east, according to the succession of signs; for the swifter that the sun is in his annual motion from west to east, the slower he must be in diurnal motion from east to west, as is plain by the figure in the margin.

Fig. 76. vid. plate opposite p. 367. Suppose the wheel ABCDEF to move round upon the center G once in 23 hours according to the order of the letters ABC, &c. and in the same quantity of time, *viz.* 23 hours, a snail creeps the contrary way, from A to F; now although the point A is come to the place where it was, having gone once about, yet the snail wants the space FA of a whole revolution, and will not be got to the top where A is, 'till A be got so far as the point q, which will be about another hour, and if the snail had moved yet faster, so that in 23 hours she had got from A to E, she would have been yet so much longer in arriving at the top: *viz.* about 25 hours; from hence it is plain, that the faster the snail creeps from A towards F, E, &c. the longer she is in coming to the top of the wheel moving the contrary way, and consequently the faster the sun moves from west to east in his annual motion according to the succession of signs, the longer he is in making one diurnal revolution; and although the sun's revolution from the meridian to the same meridian again always determines the 24 hours, yet it is plain from hence that every 24 hours by the sun is not exactly the same equal space of time, which in process of time makes a small difference between the sun and a good watch, and is the occasion of the aforesaid equation of time.

The inequality of the sun's motion proceeds from a two-fold cause.

This first cause is the obliquity of the ecliptick, making an angle with the equator of 23—30m. or thereabouts; now the ecliptic being properly an oblique circle, the poles of the equator, and not of the ecliptick, being the poles of the world, and the center of all diurnal motion, the right ascension of the sun must be accounted upon the equator; and hence it is manifest, that although the motion of the sun in the ecliptic were always equal, yet his motion from west to east, or his right ascension accounted upon the equator, could not be so much, or increase so fast in Aries or Libra, where the ecliptick makes an angle of 23 deg. 30 min. with the equator as in Cancer and Capricorn, where the sun's way in the ecliptic is parallel to the equator.

Fig. 24. vid. plate opposite p. 367. For illustration of what hath been said, suppose the line ABCD to represent the half equator, and the arch

AFED,

AFED, to represent half of the ecliptick, now although the segments AF and FE and ED are equal, yet perpendiculars let fall from the points F and E upon the line A B C D, at the points B and C do not divide that line into three equal parts, from whence it is plain, that the sun's right ascension DC is not so much increased by his running from D to E at so great an obliquity to the equator, as the sun's right ascension CB is in his running from E to F, where his motion is almost parallel to the equator; and then if his motion from west to east be swiftest in the tropicks for reasons now given, his diurnal motion must be slower by the first demonstration.

But a second cause of this inequality is occasioned by the eccentricity of the sun's orb (whether we allow the sun or earth the motion it matters not, but in this case we shall impute the motion to the sun) which moves in his orb sometimes nearer, sometimes farther off from the earth, by which means although the sun's motion in his orb were always equal, yet it would appear to us to be sometimes swifter than at other times from west to east, and consequently slower in his diurnal motion, as you see demonstrated in the following figure.

Fig. 15. *vide plate opposite page* 367.

In this diagram suppose the earth at the center, about which is described the circle ABCD, which is equally divided into 12 parts, at the points A. 1. 2. B. 3. 4, &c. representing the 12 signs which in themselves are equally divided. Now if the sun did move in the circle ABCD, which is equally distant from the earth its center at E, his motion would be regular and certain, but the earth being not the exact center of the sun's orb, makes the division of the signs although equal in themselves, to appear unequal to us; for the illustration of which, suppose the sun to move in the uppermost circle, marked ♈ ♉ ♊, &c. whose center is at the mark ⊙, and suppose the earth at the center of the other circle near the mark E: now although with respect to the center E, the divisions or lines drawn from thence are equally distant, yet these lines continued to the uppermost circle in which the sun is supposed to move, the divisions upon that circle are very unequal, and therefore although the sun's proper simple motion should be always equal, yet it is very plain that the sun in Capricorn when nearest the earth, shall appear to us to run more swift, than when in Cancer, in his aphelion or greatest distance from the earth, by reason of the smaller division of the signs, not that they are really so, but appear

appear so to us, because of the nearness of the sun's orb to the earth, as you see the points ♈ and ♎ are diametrically opposite to each other, supposing the eye at the center E, where the earth is supposed to be, and the far greater part of the circle is above the line ♈ ♎ which yet contains but six signs, and the far lesser part is below that line which contains also six signs, and yet the signs equally divided upon that circle, whereof the earth is supposed to be the center.

Note, I am not here undertaking to determine whether the sun or earth be the center of the world, or whether the orbs of the planets be circular or elliptical; for which way soever it be, this demonstration serves to illustrate what I am now upon, as to the equation of time; and to let the reader see the reasons thereof, which is all that is expected from this diagram.

Now the occasion of this equation being twofold, as is proved, it is plain, that when both the inequalities tend one way, it alters the equation faster, as about the middle of December, when the sun is nearest the earth, he appears to move faster from west to east by the last demonstration; and also running then almost parallel to the equator, his motion, according to the succession of signs, must be swift, by the second demonstration; and therefore his diurnal motion or revolution from noon to noon, must require more time, by the first demonstration, and consequently the watches must now go faster than the sun; but in June, although that part of the eclipticк in which he then is, lies nearly parallel to the equator, as in December, thereby acclerating his easterly motion, to our appearance; yet his distance from the earth being then in Aphelion, helps to retard it, so that the motion of the equation, is not then so evident.

From this inequality, as grounded by these two occasions, are the foregoing tables of equation of time calculated, which will serve for many years, without any sensible alteration. Their use is so plain, that every body may understand it; for find the month at the top of the leaf, and the day at the left hand, and in the common angle of meeting, you have the equation in minutes and seconds, whether it be too fast or too slow; as the title [watch too fast] or [watch too slow] directs.

And now for the application hereof to the finding the longitude; when you set sail observe in your table of equation of time, how much the watch is too fast or two slow, and set your

your watch to it, and not exactly to the time of the day, unless it be when the equation is nothing. As for example, suppose I am bound upon a voyage any day when the equation found in table is seven minutes, and the title [watch too slow] I conclude from thence, that a good watch should be seven minutes too slow, or behind the time given by a true sun-dial, therefore I put my watch seven minutes behind the time given by the sun. As suppose I set my watch at 12 o'clock, I put it to 53 minutes past 11, or if I set it at 4, I put it to 53 minutes past 3, *&c.* and laying it carefully by, as before directed, it is fit for the voyage.

Suppose I have sailed several days to the westward of the meridian departed from, but whether northwards or southwards it matters not, finding the sun just upon the meridian, I look at my watch, and find it 16 minutes past 3 o'clock, and looking in the equation table, I find *watch too fast* 12 minutes, therefore I subtract 12 minutes from the time given by the watch 3 hours, 16 minutes, the remainder 3 hours 4 minutes, reduces as before directed, gives 46 deg. 0 min. The true difference of longitude; but if it had been too slow 12 min. you must have added 12 min. to 3 h. 16m. *&c.*

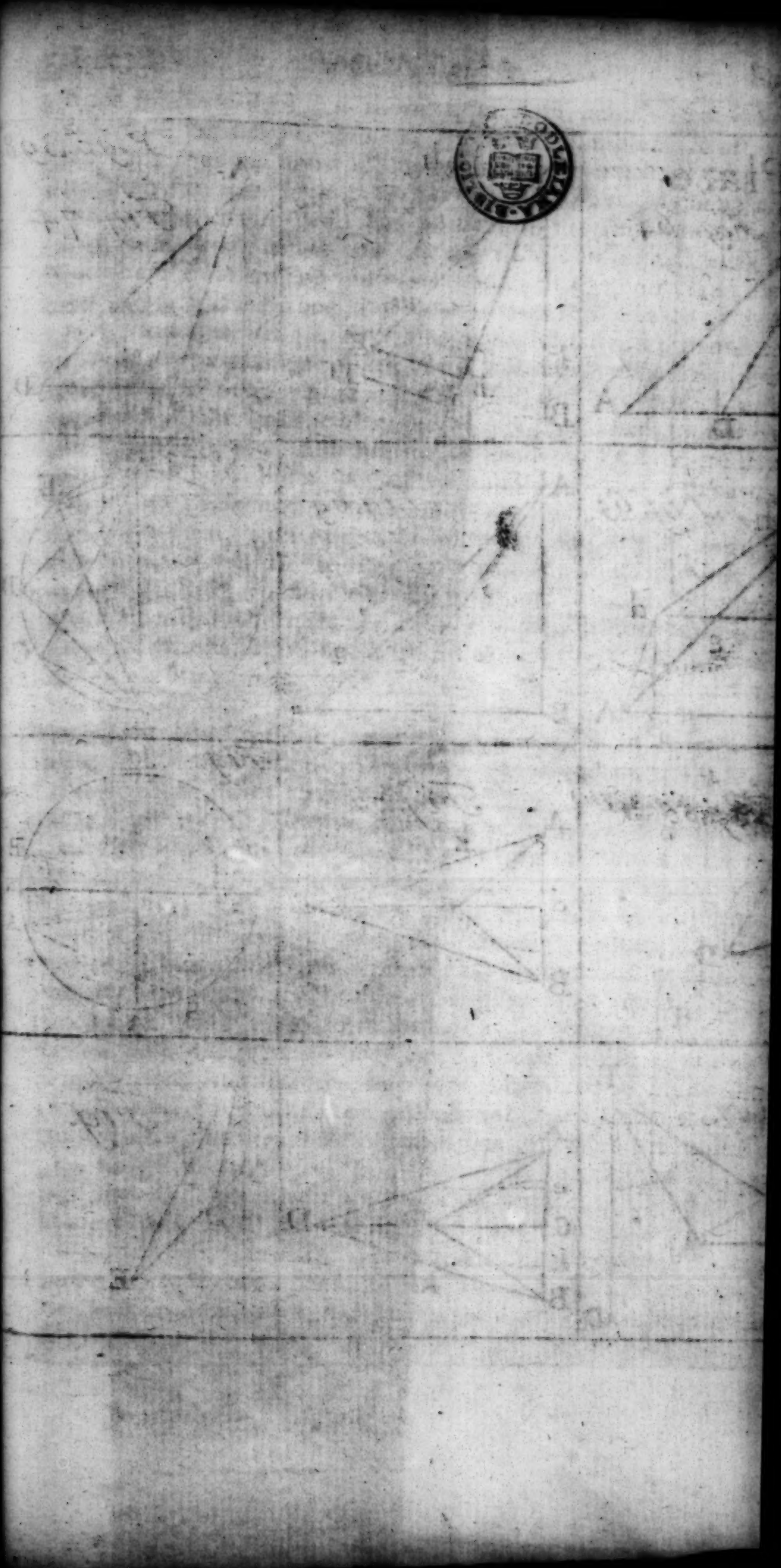
Note, If you set your watch exactly with the sun when the equation is nothing, it will always after that hold the same equation found in the table, whether too fast or too slow, and the same quantity, (if your watch go right) and that is the reason, that if you set your watch when there is equation, you must give it the equation answering to that day, (whether swift or slow) and then it will also hold the same equation.

If any body will object, that if a watch proves wrong and erronous, it may cause a great error to be contracted in this way of finding the longitude, according to the slowness or swiftness of the watch.

I answer, that I agree to; but nevertheless when watches, as well as other instruments, are made by a good workman, and sold to a gentleman for good and substantial, it is commonly expected that they should answer the end for which they are made and bought; and if we will suffer this objection to prevail yet farther, I answer, that with respect to the latitude, it may as well be urged, that if our quadrant, fore-staves, or other instruments for that purpose were made wrong, we should be much deceived in our observations for the latitude; and (yet

(yet how few upon such suppositions will foolishly desist from the use of those instruments for attaining the latitude; nay, so far are they from that, that when they find an apparent fault in a quadrant, they will observe carefully what the fault is, whether northerly or southerly, and how much, thereby to regulate their future observations; and when all is done, you shall rarely find whether there are many quadrants, or many observers aboard of one and the same ship, and observing at one and the same time, that all their observations shall be exactly the same, but differ sometimes 6, 8, 10, or 20 minutes, or sometimes more; and yet these differences are thought tolerable, and the mariners continue to use these means, and in a great measure to trust to them notwithstanding; for we must not expect to attain to infalibility in any respect, whilst we are traversing this terraqueous globe———Not that I would advise any body to be too credulous, or to take either watches, or other instruments, and trust to them as the best, meerly upon the report of another, unless you know you have great reason to depend upon the credit of them that so recommend them: But if you think to make use of this Method for finding the longitude at sea, take a watch along with you, that you have had some experience of a shore, and if you have found that your watch has gone well ashore, and yet fear, that for the reasons before mentioned, she may not go so well at sea, take her along with you upon some short coast voyage, where you can every now and then observe whether she keeps her true motion at sea as well as ashore, and if you find that notwithstanding your keeping her so carefully, as before directed, the clamminess of the sea-air, does (as some suppose) retard her motion, you may use means to quicken her motion as much as to counterballance her dulness occasioned by the sea-air, if any such thing be, (which I cannot believe, if she be kept warm and dry, as before directed) and by this means I do not question, but that this method for finding the longitude might be rendered as easy and practicable as the common methods now in use, for finding the latitude by observation, a thing very desirable, and therefore deserves to be encouraged, and put in practice.

I know it is argued by sailors, (and with good reason too) that in places near the equinoctial, the degrees of latitude and longitude are so nearly equal, and that the Mercator's chart and the plain chart are so much alike, that longitude there need not be much regarded; but the greatest necessity for it



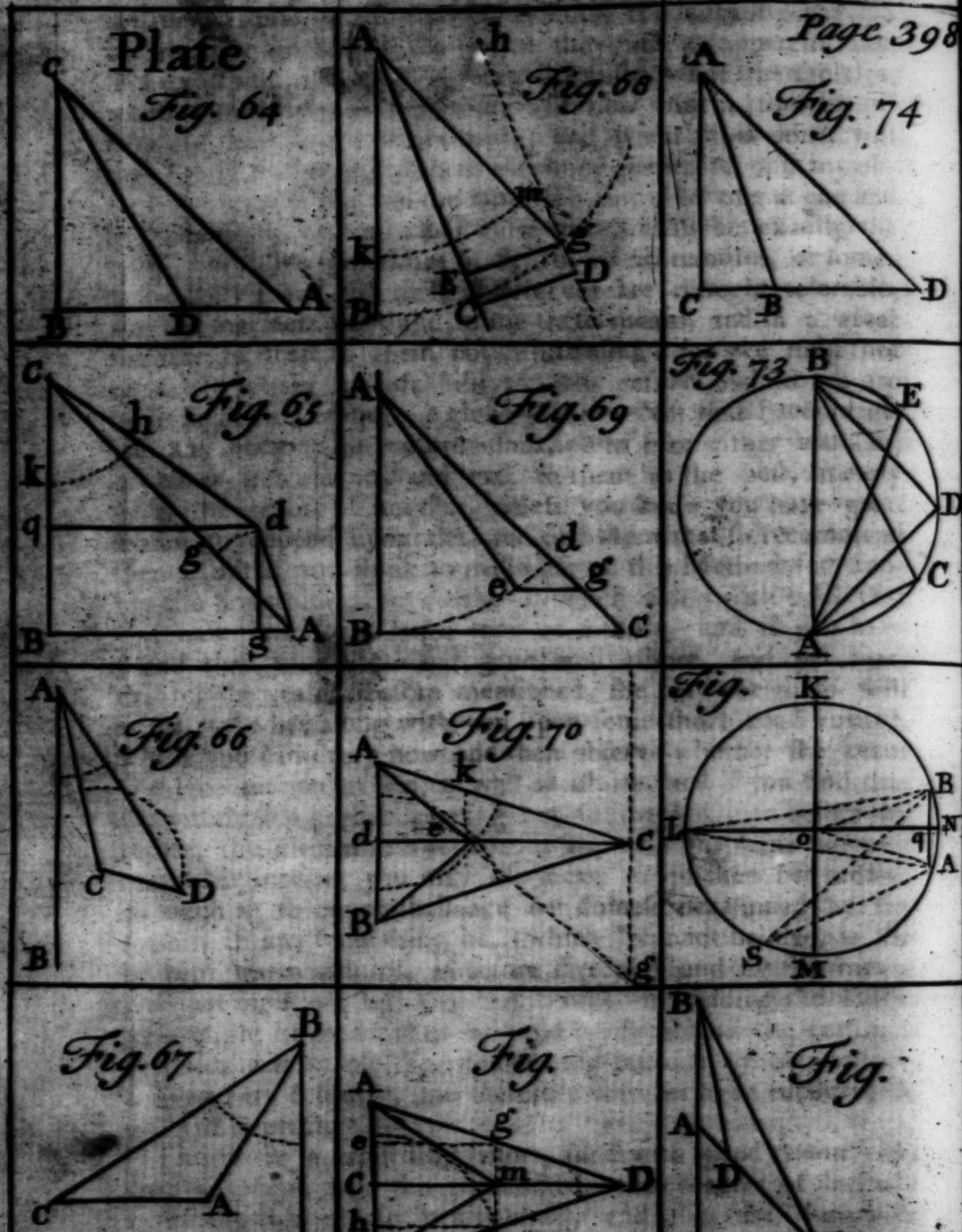


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Fig.
Fig.

it, and difficulty in attaining it, is in places nearer the pole, especially above 60 degrees of latitude, where a degree of longitude contains not half so many miles as a degree of latitude, which makes the work more difficult.

I answer, for the encouragement of those that would put in practice what is here delivered, that the nearer the poles that you come, and consequently the lesser the degrees of longitude, are, the more practicable is this method, and the less the errors that can be supposed to be contracted; for in a few miles westing or easting in latitudes above 60, where the degrees of longitude are not half so much as a degree in the equinoctial, you may much more sensibly and apparently discern your difference of longitude there than nearer the equinoctial. I have been my self running five or six knots due west in latitude 72d. 30m. or thereabouts, (I do not exactly remember, but it was in coming from Archangle, about the north cape of Pinmark, the cape itself lies in latitude 71d. 22m. and we did not make the cape coming home) and in 24 hours running, I could very sensibly discern that we had gained about half an hour: so that when the glasses were out for 12 o'clock, (which we had formerly experienced to be very right) it wanted about half an hour of 12 by the sun, as near as I could compute, having no help but the ship's glasses to compute it by: the truth of which is also evident; for in latitude 72d. 30m. there is about 18 miles to a degree, and if we run about 135 miles that 24 hours, which might be done at the rate abovesaid, it would answer exactly to 7½d. 30m. of longitude, which is just half an hour in time; and hence it is plain that the difference of longitude by this method is more preceptible in great latitudes than near the equinoctial.

And that the errors here contracted are also less is as evident: for suppose your watch to be wrong by 4 minutes of time, this 4 minutes, I confess, is a degree of longitude in all latitudes, and in that respect the error is equal in all latitudes: but when the longitudes comes to be reduced to miles, such whereof 60 makes a degree of a great circle upon the earth, you will find that a degree at or near the equinoctial, is about 60 miles, and therefore an error of 4 minutes in time, begets an error of sixty miles near the equinoctial; but in latitude 72d. 30m. aforesaid, where there is but 18 miles to a degree, an error of 4 minutes of time begets an error of but 18 miles in dis-

tance; and further north, where the attaining of longitude is yet more difficult, the errors contracted by this operation will consequently be less, an error of six leagues being as discernable in latitude 72d. 30m. as an error of 20 leagues near the equinoctial; so that although sailing near the equinoctial is commonly reckoned the easiest in all other cases, yet by this method the most difficult tasks are become the most practicable and easy: and I think I may, without presumption, entitle it as useful an help for finding the longitude as what has yet been offered, and may be very assisting in that useful subject, till (if possible) the desired complestment thereof be accomplished.

The End of the New Method.

The description and use of the sea quadrant, commonly called Davis's Quadrant: by the French, the English Quadrant.

S. WHAT are the chief parts of this instrument?

T. The chief parts of it are 2 arches, (a lesser and a greater) and 3 vanes.

S. How do you call the lesser arch *e d*?

T. It is called the Sixty Arch, because it contains 60 degrees.

S. Why is this arch made less than that of *g f*, which contains but half so many degrees?

T. It is to the end that the shadow of the vane B, which is placed on it, (or rather the beams of the sun, which pass the hole and glass of the said vane) may appear the better upon the vane A.

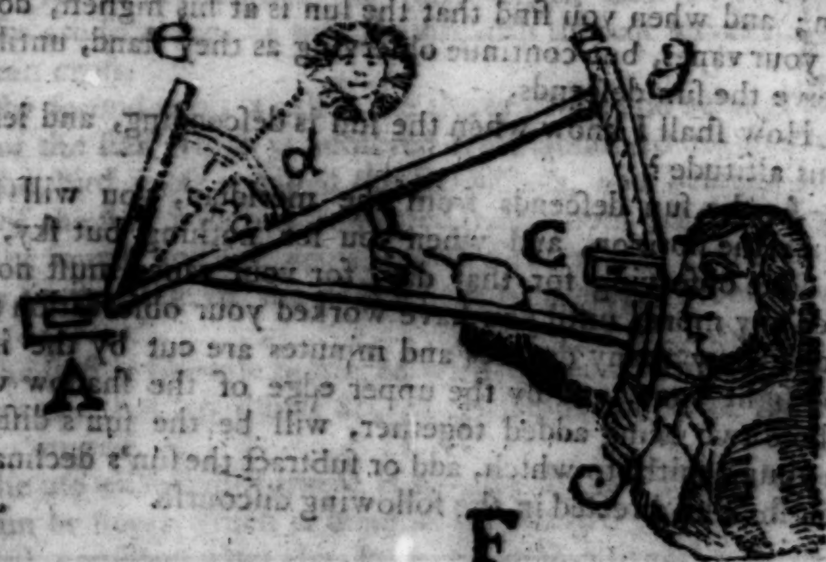
S. How do you call the greatest arch *g f*?

T. It is called the Thirty Arch, because it contains 30 degrees.

S. Why is this arch made upon a larger radius than *e d*?

T. It is to the end that it may be the better divided into degrees and minutes, and that those degrees being bigger, the observation may be the more exact.

S. How do you call the vane A?



T. The

T. The Horizon Vane, and the next to it at B, is called Shadow Vane; and the third Vane C, is named the Sight Vane, because it is to be placed to your eye in the time of observation.

S. What is the use of this quadrant?

T. First, put the horizon vane on the center or end of the quadrant at A, then consider what will be near hand the complement of the sun's meridian altitude that day, and set the vane B 10, 15 or 20 degrees less than the complement of the sun's altitude, making it parallel to the horizon vane, (if you can) then turn your back to the sun, and looking through the sight at C, bring the upper edge of the shade vane, to fall upon the upper edge of the slit in the horizon vane, (but if there is a little hole with a glass in the middle of the shade vane of your quadrant, bring the beams of the sun which pass through the said hole, to fall so upon the edge of the slit in the horizon vane, as to be equally divided by it) and at the same time look through the said slit for the horizon, and if you see only sea, then slide your eye vane a little lower, towards *f*, but if on the contrary you see all sky, then remove your sight vane a little lower towards *g*, then observe again as before, continuing to move your sight vane higher or lower, until you see the shadow upon the upper edge of the slit, and at the same time the horizon, through the said slit on the horizon vane, then have you the sun's present altitude; and when he is risen a little higher, observe again, and so continue to do from time to time, and very often when you perceive he is almost upon your meridian; and when you find that the sun is at his highest, do not alter your vanes, but continue observing as they stand, until you perceive the sun descends.

S. How shall I know when the sun is descending, and lessening his altitude?

T. As the sun descends from the meridian, you will loose sight of the horizon, and when you see nothing but sky, you have done observing for that day, for your vanes must not be moved any more, until you have worked your observation thus.

Look how many degrees and minutes are cut by the inside of the sight vane, and by the upper edge of the shadow vane, for those two being added together, will be the sun's distance from your zenith, to which, add or subtract the sun's declination as you shall be directed in the following discourse.

The

The description and use of the Cross-Staff, or Fore-Staff.

THIS instrument consists of a staff and four crosses, the first and shortest is called the ten cross, and it belongs to that side of the staff which is numbred from about 3 degrees to 10 degrees. Sometimes the thirty cross, and the rest of the crosses are so made, as that the breadth thereof serves instead of the ten cross.

The second cross is called the thirty cross, and belongs to that side of the staff which is numbred from about 10 degrees to 30.

The third cross is called the sixty cross, and belongs to that side of the staff which is numbred from about 20 to 60 degrees.

The fourth and last cross is called the ninety cross, and belongs to that side of the staff which is numbred from about 30 to 90 degrees.

The staff is likewise numbred with the complement to 90 degrees, (*viz.*) at 10 stands 80, at 20 stands 70, at 30 stands 60, and so the rest.

The use of this instrument is to take the meridian altitude of the sun or stars, which is done as followeth:

First consider what the sun's greatest altitude will be that day, accordingly use the cross most suitable, (*viz.*) If the meridian altitude be judged to be under 10 degrees, use the ten-cross; if between 10 and 30 the thirty-cross; if between

30 and

30 and 60, the fixty-crofs; if between 60 and 90, the ninety-crofs, which is feldom ufed.

Having put on the crofs, place the flat end of the ftaff at A, to the outfide of the eye, as near as may be, without hindering the fight; thus the face being towards the fun or ftar, hold the crofs upright; then look at the upper end of the crofs at C, for the fun or ftar, and at the lower end at B, for the horizon, and if the fea appear inftead of the horizon, remove the crofs a little further from the eye, but if the fky appear inftead of the horizon, remove the crofs a little nearer to the eye, until the fun or ftar appear at the upper end, and the horizon at the lower end; which, when they do, then upon the fide of the ftaff belonging to the crofs ufed in obfervation, will be found the degrees and minutes of the altitude of fun or ftar. But the greateft altitude being that which is required, obfervation muft be continued as frequently as judgment fhall direct, until the fun or ftar be at the higheft; and as the fun or ftar rifes, the fky will appear inftead of the horizon; but when the fun or ftar is paft the meridian, and begins to fall, the fea will appear inftead of the horizon, and then is the obfervation finifhed; and upon the fide of the ftaff, proper to the crofs ufed, are found the degrees and minutes of the fun's meridian altitude; which fubtracted from 90 degrees, gives the complement of the altitude; or it may be taken off the ftaff at once (the ftaff being numbred with the complement, as is fhewed before) with which, to proceed in finding the latitude of the place, obferve the rules and directions aforegoing.

A Table

A Table of Latitude and Longitude of the Principal Harbours, Headlands, and Islands in the World: Corrected by the latest and best Observations; the Longitude reckoned from the Meridian of LONDON.

Note, *When the Latitude and Longitude of an Island is given, the Middle of the Island is meant, except some particular Part of it is expressed.*

Places Names.	Lat. North		Long. E or W	
The Coast of England.	D.	M.	D.	M.
	North Latitude		West Longitude	
BErwick -	55	48	01	45 W
Newcastle	55	12	01	30 W
Stockton - -	54	33	01	25 W
Spurn - - -	53	45	00	13 E
Yarmouth - -	52	40	01	38 E
LONDON	51	31	00	00 E
North Foreland	51	25	01	24 E
Beachy - - -	50	46	00	25 E
Dunmose Isle Wight	50	38	01	24
Portland - -	50	30	02	44
Start Point -	50	07	03	47
LIZARD	49	57	05	4
Land's-end -	50	06	06	00
St. Mary's Scilly	50	00	06	06
Hartland Point -	51	06	04	35
Lundy Isle - -	51	20	04	40
Bristol - - -	51	33	04	15
St. David's head	51	00	05	22
Barsey Isle - -	52	44	05	00
Holy-head - -	53	24	04	50
Liverpool - -	53	20	03	00
Whitehaven -	53	17	03	30
Carlisle - - -	54	47	03	05
The Coast of Scotland.				
	N. Lat.		W. Long.	
Glascow - -	55	52	04	05
N. Part of Sky Isle	57	45	05	45
North Part of Lewis Island	58	20	07	20
	North Lat.		West Long.	
St. Kilday - -	57	52	09	45
Farro Head -	58	34	05	10
Northern Isles of Orkney	59	10	03	22
Shetland S. Point	60	04	02	00
Buchaness - -	57	45	01	18
Aberdeen - -	57	22	01	40
Dundee - -	56	28	02	40
Edenburgh - -	55	58	02	59
The Coast of Ireland.				
	North Latitude.		W. Long.	
Dublin - -	53	12	06	56
Wexford - -	52	13	07	27
Waterford - -	52	09	08	40
Cork - - -	51	49	09	30
Cape Clear - -	51	17	11	10
Limerick - -	52	23	09	35
Galway - - -	53	07	09	40
Sline Head - -	53	20	11	15
Londonderry -	55	00	07	50
Belfast - - -	54	39	06	30
Coast of Holland and Flanders.				
	N. Lat.		E. Long.	
Scaw - -	57	20	10	20
Helighland - -	54	24	07	35
Hambrough -	53	41	10	35
Emden - - -	53	25	07	35
The Fly - -	53	16	05	30
The Texel - -	53	15	05	10

Amsterdam

Places Names.	Latit. North D.	M.		Long. E or W D.	M.	
Amsterdam	52	23	N. Lat.	05	24	W. Long.
Rotterdam	51	55		04	00	
The Brill	52	00		04	00	
Sluys	51	14		0	130	
Calais	50	58		0	54	
Coast of France and Portugal.						
Dieppe	49	56		01	09	E
Cape de Hogue	49	47		02	00	
Caskets	49	50		02	20	
Guernsey	49	33		02	40	
St. Maloes	48	39		01	52	
Morlaix	48	33		03	49	
Ushant	48	30		05	02	
Brest	48	23		04	25	
Penmark	47	48		04	24	
Bell Isle	47	18	North Latitude	03	16	West Longitude
Nantz	47	14		01	39	
Island Dieu	46	34		02	13	
Island Rey	46	10		01	30	
Rochel	46	10		01	11	
Bourdeaux	44	50		00	38	
Bilboa	43	29		02	58	
Cape Ortegal	44	04		07	48	
Cape Finister	43	12		09	40	
Port a Port	41	10		00	25	
Burlings	39	35		09	24	
Rock of Lisbon	38	52		09	50	
Lisbon	38	42		08	53	
Cape St. Vincent	36	53		09	06	
Cadiz	35	33		06	01	
Cape Trefalga	36	10		06	01	
The Coast on the Main Continent within the Straits.						
Gibraltar	36	12	N. Lat.	04	53	W. Lon.
Cape de Gat	36	40		01	40	
Cape Paul	38	15		00	05	
Cape St. Martin	38	46		00	40	

Places Names.	Lat. North D.	M.		Longit. E or W. D.	M.	
Barcelona	41	26		02	18	
Marseilles	43	18		05	27	
Toulon	43	07		06	02	
Genoa	44	25		08	43	
Leghorn	43	28		10	35	
Rome	41	54		12	45	
Naples	40	51		14	46	
C. Spartavento	37	55		16	55	
Cape Collone	38	56		18	05	
Gallipoli	39	56		18	43	
Cape St. Mary	39	45		19	00	
Ancona	42	10		14	26	
Venice	45	25		12	10	
Lepanto	38	10		22	52	
Cape Matapan	36	33		22	41	
Cape St. Angelo	36	32		23	56	
Athens	37	58		24	05	
C. Martelo S. P. of Negropont	38	07	North Latitude.	25	03	East Longitude.
C. Monte Sancto	40	26		25	02	
Salonica	40	41		23	13	
Gallipoli	40	33		27	20	
Constantinople	40	59		28	56	
Smyrna	38	28		27	25	
Ephesua	38	01		27	53	
Antiochetta	36	30		32	46	
Scandaroon	36	34		36	30	
Aleppo	35	42		37	24	
Tripoli	34	38		36	15	
Alexandria	31	10		30	19	
Cape Rusato	32	48		21	25	
Cape Mesurato	32	21		16	17	
Tripoly	32	54		13	10	
Cape Bona	37	03		11	04	
Bona	37	02		08	9	
Algier	37	50		02	16	
C. de tres forcas	35	30		02	04	W
Tetuan	35	27		05	06	W
Ceuta	35	54		04	45	W
Tangier	35	42		05	22	W
Alboran						

Places Names.	Latit. North D.	M.	Long. E or W. D.	M.
Islands within the Straits.				
Albaran	35	54	02	29 W
Formentura	38	33	01	55
Ivica	38	50	01	40
Majorca	39	30	03	03
Minorca City	39	51	04	52
Port Mahon, Minorca	39	42	04	12
Gallitra	37	41	08	44
Sardinia, S. End	38	46	09	12
Corsica, N. End	42	56	09	50
Gorgona	43	34	09	58
Capsia	43	03	10	27
Lilboa, or Elba	42	45	11	00
Messina	38	07	16	20
Maritimo	38	08	12	15
Cape Passaro	36	38	15	40
Malta	35	53	14	38
Corfu	39	42	20	06
Chephalenia	38	15	21	00
Zante	37	46	21	14
Modon, or Morea	36	52	21	32
Lemnos	39	59	25	37
Scio	38	22	26	12
Lissa	43	06	16	40
C. St. John, W. E. of Candy	35	15	24	00
C. Solomon, E. of Candy	35	20	27	08
Rhodes City	3[illegible]	42	28	05
West End of Cyprus	34	57	32	23
East End of Cyprus	35	31	36	00

North Latitude. East Longitude.

Places Names.	D.	M.	D.	M.
The Coast of Barbary and Guinea.				
Cape Spartel	35	50	05	49
Sallee	33	51	06	25
Cape Cantin	32	36	09	10

N. La. W. Lo.

Places Names.	Lat. N. or S. D.	M.	Long. E or W. D.	M.
Cape de Geer	30	27	10	06
Cape Bajadore	26	04	15	35
Cape Oleado	23	41	15	90
Cape Blanco	20	32	17	35
Senegall	15	28	16	25
Cape de Verde	14	45	17	20
River Gambia	12	08	15	31
Sierraleona	08	36	12	57
Mezfurado	06	05	10	02
Cape Palmas	04	13	06	45
Jaque Jaque	04	16	09	47
Allene	04	15	07	17
Cape 3 Points	04	28	01	50
River Volta	05	55	03	25
River Formosa	07	00	07	20
Capo Formosa	04	15	06	40
New Calabar	04	42	08	33
Old Calabar	04	10	09	45
Riv. Camerones	03	25	10	10
River de Angra	00	50	10	01
C. Lopas	00	55	09	55
River Congo	05	40	15	25
Angola	08	57	15	56
Cape Negro	16	08	12	31
Cape St. Thomas	24	10	14	43
Secos	29	00	15	56
C. Bona Esperance	34	07	19	35

North Latitude. West Longitude. East Longitude. South Latitude.

Places Names.	D.	M.	D.	M.
Western Islands.				
Corvo	39	54	30	55
Flores	39	32	30	54
Fyal	38	53	28	15
Pico	38	40	27	20
St. George	38	52	26	03
Tercera	38	57	25	34
St. Michael	38	06	23	36
St. Maries	36	59	23	38

North Latitude. West Longit.

The

Places Names.	Lat. N. or S. D.	M.		Long. E or W D.	M.	
The Canary Islands			South Latitude			East Longitude
Ferro	27	54		17	45	
Palma	28	40		17	36	
Gomero	28	06		17	05	
Teneriff	28	23		16	28	
Madeira, West End	32	23		17	26	
Porto Sancto	32	58		15	54	
Canaria	27	52		15	10	
Forteventura, S. W.	28	05		13	36	
Lancerota	29	02		12	45	
Cape de Verde Islands.			North Latitude			West Longitude
St. Antonio	17	24		25	02	
St. Vincent	17	04		24	39	
St. Lucia	17	05		24	40	
St. Nicholas	16	50		2[illegible]	58	
Brava's	14	28		24	02	
Fuego	14	50		23	41	
St. Jago	15	08		22	56	
Isle of May	15	14		22	02	
Isle of Sal	16	15		22	08	
Bonavista	16	05		22	07	
Southern Islands.						
St. Matthew's	01	30	S	06	01	W
Ascension	07	40	S	14	25	W
St. Helena	16	00	S	06	14	W
Fernande Poo	02	40	N	10	30	E
Princeps	01	40	N	09	15	E
St. Thomas	00	00	N	08	20	E
Annabona	02	10	S	07	27	E
The Coast on the Main Continent in the East-Indies.						E. Long.
Cape Lagullas	34	54	S	21	20	
C. Bona Esperance	34	07	S	19	35	
Cape Corientes	23	40	S	36	17	
Mosambique	15	04	S	41	10	

Places Names.	Latit. N. or S. D.	M.		Longit. East. D.	M.	
River de Fuegos	00	41	S	41	15	
			North Latitude			East Longitude
Cape Bassos	04	06		47	38	
Cape Guardefoy	11	44		51	20	
Cape Rasulgat	22	41		59	45	
C. Mucaor Muscat	22	32		59	45	
Busero	29	45		49	20	
Surat	21	10		72	25	
Goa	15	31		73	50	
Callecut	11	16		75	30	
Cochin	09	54		75	55	
Cape Comerine	07	50		77	25	
Fort St. George	13	11		80	32	
Diu Point	16	08		81	32	
Visagapatam	17	43		83	57	
Cape Palmiras	20	42		87	52	
Ballasore Road	21	16		87	48	
Bengal	22	17		92	21	
Cape Negrais	26	23		93	00	
Malacca	02	12		102	10	
Siam Entrance	14	18		100	55	
Cambodia Entr.	10	28		105	00	
Cochin	14	05		107	16	
Macao	22	13		113	51	
Canton	23	14		113	06	
Amoy or Quemoy	24	35		116	50	
Laimpo	29	59		120	35	
Nanquin	33	45		120	01	
Islands in the East-Indies.			South Latitude			East Longitude.
Madagascar, S. end	25	47		46	10	
St. Laurence, N. end	12	10		51	05	
Mayetta	13	10		45	38	
Mohilla	12	05		44	23	
Comero	11	40		42	50	
Juan de Nova	09	30		52	40	
Mauritius	20	10		52	55	
Diego Royes	19	50		61	30	

Romeras

Places Names.	Latit. N. or S. D.	M.		Long. East. D.	M.	
Romeras de Castelamas	28	45	South Latitude.	67	17	East Longitude
Amsterdam	38	40		72	45	
St. Brandon	16	38		64	30	
Diego Gratiosa	08	40		68	25	
Quabella	0[illegible]	53		52	36	
Bassas de Chagos	06	55		68	45	
Yas de Diego Reys	00	20	North Latitude.	72	00	
Maldivia N. end	07	14		73	04	
Maldivia S. end	00	25		76	22	
Malique	09	00		72	58	
Sacatra	12	21		54	05	
Abdeleur	12	04		53	04	
Cape Gallo de Zeylone	06	08		81	15	
Yas de Amber	00	00		52	30	
Andaman	11	10		73	32	
Nicobar	07	11		93	40	
Sumatra N.W. end	05	22		94	50	
Verkin's Island	02	22		94	07	
Nassau Island	02	54	South Latitude.	99	32	
Bencola	03	55		104	08	
Sumatra, S. E. end	05	22		105	10	
Enganoor Trompeus	05	50		101	43	
Selam	08	20		102	13	
Princes Island	06	30		104	02	
Bantam in Java	06	11		105	55	
Batavia	06	16		106	46	
Java East End	08	22		112	33	
Straits of Sundy	06	02		105	46	
Banca. S End	03	20		106	45	
Borneo, S. Point	03	54		113	37	
Banda Isles	04	55		127	17	
Celebes S end	05	10		119	07	
Celebes N. end	01	30	N. Latitude.	121	20	
Mindano W. point	06	40		119	15	
Borneo N point	07	40		113	05	
Luconia S.W. p.	12	30		120	10	
Luconia N.E. p.	18	55		120	05	
Anian N.W. po.	19	30		107	00	
Anian N.E. poi.	19	55		109	55	

Places Names.	Lat. N. or S. D.	M.		Long. E. or W. D.	M.	
Formosa S. po.	22	00	North Lat.	119	56	East Longitude
Formosa N. p.	25	30		120	45	
Piscadore Isles	23	30		118	35	
Island Chusan	30	38		120	35	
Japan S.E. po.	35	30		140	30	
Japan S.W. p.	35	00		128	30	

The Coast of America in the S. Sea from California to C. Horn.

Places Names.	Lat. D.	M.		Long. D.	M.	
C. St. Sebastian	42	45	North Latitude	127	35	West Longitude
C. St. Lucas or Lucar	23	20		111	46	
C. Corientes	18	50		110	30	
Aquapulco	17	05		104	18	
Aquatulco	15	27		102	03	
Guatimala	14	25		101	00	
Panama	08	50		81	52	
B. Bonaventuro	03	24		78	06	
Isl. Gallopega	00	00		90	10	
C. del Ajuga	06	30	South Latitude.	84	50	
Lima	12	15		77	30	
Arica	18	29		73	10	
La Serena	29	00		76	22	
Isl. J Fernandes	3[illegible]	15		8[illegible]	18	
Baldivia	35	35		81	10	
Port Stephen	46	50		82	36	
Cape Victory	52	00		83	10	
Cape Horn	56	55		79	55	

The Coast of Brazil in S. America from Cape Horn to Cape Roque.

Places Names.	Lat. D.	M.		Long. D.	M.	
Magellan E. entr.	52	00	South Latitude	75	05	West Longitude
River Julian	48	40		74	34	
Cape Blanco, near River Camerones	46	50		72	07	
Buenos Ayres, Riv. Plata	34	35		57	54	
River Grand	31	55		52	00	
St. Catherine's	27	50		49	00	

Places Names.	Latit. N. or S. D.	M.	Long. West. D.	M.
	South Latitude		West Longit.	
Cape Frio — —	23	00	42	20
Spirito Sancto —	19	59	42	10
P. Segura — —	16	31	40	35
B. Todos Sanctos	12	46	41	00
R. St. Francisco	10	50	37	50
Olinda, or Pernambuco	07	48	35	30
C. St. Augustin	08	35	35	20
Cape Roque ——	05	00	35	47
Tristian D' Acunha	37	05	33	50
Trinidada — —	20	30	30	00
The Coast of the Main Continent in the West-Indies.				
	North Latitude		West Latitude	
R. Amazones ent.	00	00	49	56
North Cape —	02	05	49	56
Surinam — —	06	25	56	50
Oronoque — —	08	15	59	25
C. Conquibaca	12	40	70	42
Carthagena — —	10	28	7[illegible]	21
Scot's Settlement	08	[illegible]0	78	45
Nicaragua Entr.	11	25	84	15
Cape Catocha —	21	10	86	0
Campecha — —	19	30	92	10
La Vera Cruz —	19	12	9[illegible]	48
Mexico — —	20	[illegible]0	10[illegible]	35
Escondido ——	30	20	8[illegible]	30
Cape Florida —	24	57	80	30
The Charibbee Islands.				
	North Latit.		West Longit.	
Trinidada — —	10	15	60	17
Tobago, W. end	11	10	59	10
Granado —— —	11	57	60	20
Barbadoes ——	12	58	58	50
St. Vincent ——	13	12	60	12
St. Lucia ——	13	55	60	04
Martinico ——	14	43	60	54
Dominico ——	15	23	60	30
Maggallante ——	15	58	60	20
Guardalupa ——	16	10	61	15

Places Names.	Latit. North D.	M.	Long. West. D.	M.
	North Latitude		West Longitude	
Monserat — —	16	45	62	15
Antegua — —	17	05	61	45
Nevis —— ——	17	05	62	32
St. Christopher's	17	17	62	40
Barbuda — — —	17	56	60	40
S. Bartholomew	17	52	62	06
St. Martin's ——	18	06	62	10
Anguilla —— —	18	17	62	13
Virgin's — ——	18	30	63	25
St. Cruize ——	17	52	63	36
Bieque ——	18	00	63	15
Porto Rico St. John's	18	30	65	37
St. Dom. Hisp.	18	25	69	30
P. R. Jamaica —	17	40	76	32
E. end of Cuba -	20	15	73	55
Havanna — ——	22	40	82	55
Bay Hondy — —	22	45	83	40
C. St. Antonio	21	45	85	32
Bahama Islands.				
	North Latitude		West Longitude	
Bermudas — —	32	25	63	40
N. Point Bahama Bank	27	[illegible]0	78	35
Bahama Island —	2[illegible]	[illegible]0	79	36
Abaco S. Point —	2[illegible]	[illegible]0	73	46
Harbour Island	2[illegible]	[illegible]7	76	47
Andross N. Point	2[illegible]	10	78	50
Providence — —	25	00	77	20
Eleuthera S. Point	24	40	75	56
Cat Island — —	24	25	75	09
Watling's Island	24	03	74	35
Rum Key ——	2[illegible]	45	74	50
Exuma — — —	2[illegible]	22	75	55
Crooked Isle N. Point	22	56	74	12
Atkins's Key —	22	17	74	05
Meraparvouz —	21	58	74	45
Atwood Keys —	23	10	73	35
French Keys —	22	40	73	40
Mayaguana —	22	35	72	46
Hogsties —— —	21	17	73	55

Places Names.	Lat. North D.	M.	Longi. West. D.	M.	
Hyneago W. end	20	52	73	46	N. Lat. W. Long.
Caicos Bank N. po.	20	50	71	15	
Turk's Island —	21	35	70	08	
Abroloo N. point	21	35	69	06	
Platewrack — —	20	10	68	15	
The Coast of Carolina, Virginia, Maryland, Pensylvania, New-England, and New-foundland.					
Charles Town on Ashly river	33	05	78	46	North Latitude. West Longitude
Cape Hatteras -	35	15	74	20	
Cape Henry -	37	00	75	24	
Cape Charles -	37	16	74	16	
Cape Hinlopen	38	50	74	[illegible]6	
Long Island -	40	50	72	45	
New York - -	4[illegible]	58	7[illegible]	53	
Cape Cod - -	42	12	6[illegible]	55	
Boston Entrance	42	30	6[illegible]	[illegible]3	
Cape Sable - -	43	50	6[illegible]	[illegible]8	
Island Sable -	44	20	59	[illegible]	
Cape Britain -	46	00	5[illegible]	30	
Quebeck - -	46	55	6[illegible]	48	
Bay of Brest -	52	10	56	57	
Bell Island - -	52	07	55	35	
Cape St. John -	50	25	52	48	
Cape Bonavista -	49	15	52	12	
Trin. Bay entran.	48	52	52	20	
Concep. Bay ent.	48	20	52	08	
St. John's Harb.	48	00	51	39	
Bay of Bulls -	47	50	51	29	
Cape Race - -	46	40	51	52	
Cape St. Mary -	47	10	53	23	
Placentia Bay -	47	45	53	58	
Cape Roy - -	48	00	57	40	
The Coast of Hudson's Bay and the Straits.					
Button's Isles -	60	25 N	66	27 W	
Cape Charles -	62	10 N	75	35 W	

Places Names.	Lat. North D.	M.	Long. E or W D.	M.	
Cape Walsingham - -	62	35	77	55	North Latitude. West Longitude
Mansfield Isle -	61	42	80	30	
Cape Jones - -	54	55	78	58	
Rupert's River -	51	30	79	26	
Albany Fort -	52	26	84	50	
The Cubbs -	54	10	82	40	
C. Hen. Maria	55	07	84	30	
Port Nelson -	57	10	93	58	
Cape Churchill -	59	00	95	20	
Cape Southampton	61	55	86	48	
Shark Point -	64	30	82	55	
Nottingham Isle	63	30	79	53	
Queen Ann's Foreland -	63	48	74	45	
Resolution Isle -	61	50	65	04	
Cape Farewel -	59	45	46	45	
The Coast of Iceland, Greenland, Nova Zembla, and the Northern Isles.					
Sound Royal -	66	22	24	33	North Latitude West Longitude
Bargarer's Point	66	20	16	35	
Whale's Back -	6[illegible]	27	2[illegible]	33	
Merch. Foreland	6[illegible]	25	17	05	
Halliford - -	64	30	34	43	
Fair Foreland -	6[illegible]	20	26	27	
Grim's Isles -	67	15	22	34	
Westmania Isles	6[illegible]	30	22	54	
Isles of Fero -	62	06	05	00	
Beerenberg, or John Main's Isl.	71	45	04	30	East Longitude
Point Lookout -	76	25	15	36	
Horn Sound -	76	45	13	36	
Fair Foreland -	79	20	10	52	
Hacluit's Headl.	79	55	11	00	
Helie's Sound -	78	55	21	50	
Lee's-Foreland -	78	05	2[illegible]	25	
Whales's Head -	77	18	21	30	
Hope Island —	76	18	23	45	

Places Names.	Lat. North D.	Lat. North M.	Long. East D.	Long. East M.
Cherry or Bear Isle	74	30	18	08
Admiralty Island	75	05	59	50
Fretum Borough	70	00	61	20
Cape Candenose	69	05	42	35
Catnose - -	65	43	35	14
Archangel - -	64	30	40	13
Cross Island -	66	31	36	33
Sweetnose - -	68	10	34	45
Kilduyn - -	69	30	31	20
North Cape -	71	33	23	02
Surroy Isle - -	71	05	16	40
Tromsound -	70	25	15	30
Loefort S.W. poi.	68	15	09	30
Dronten - -	63	40	10	15
Stadland - -	62	10	04	38
North Bergen -	60	10	05	40
Naze of Norway	57	45	07	24

Sea-Coast in the Sound, and Baltic Sea.

Places Names.	N. Lat. D.	N. Lat. M.	E. Lon. D.	E. Lon. M.
Maerden, or Mardel	58	19	08	57
Larvic - -	58	54	00	20

Places Names.	Lat. North D.	Lat. North M.	Long. East D.	Long. East M.
Christiana -	59	40	10	00
Maesterland -	57	53	11	45
Gottenberg Gat	57	50	12	15
Elsenore - -	56	22	12	42
Rostock - -	54	37	18	40
Copenhagen -	55	41	13	50
Valsterborn -	55	28	12	00
Uraniburg - -	55	54	12	58
Calmer - -	56	40	16	35
Stockholm - -	59	20	19	30
Wyburg - -	60	52	29	16
Petersbourg - -	60	00	[illegible]	[illegible]
Narva - -	59	27	[illegible]	[illegible]
Revel - -	59	35	24	[illegible]
Riga - -	57	04	25	[illegible]
Derwinda - -	57	15	22	06
Coningsburg -	54	43	21	35
Dantzic - -	54	22	18	30
Wisby in Gotland	57	30	18	30
Bornholm - -	55	15	14	45
Straelsund - -	54	25	13	16
Lubec - -	54	06	09	53
Anolt, or Anholt	56	50	11	[illegible]
Leson, or Lesnou	57	05	10	30
Scaw - - -	57	30	10	20

Fig. 48

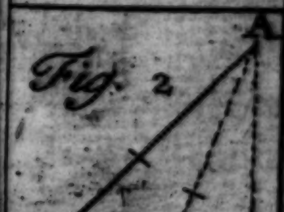


Fig. 2

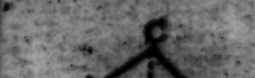


Fig. 3

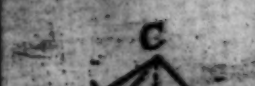


Fig. 4

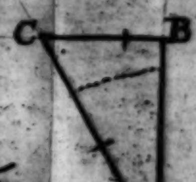


Fig. 5

EXACT

TABLES

OF THE

Sun's Declination,

From the Year 1761, to the Year 1792, for every Day at Noon under the Meridian of *LONDON*.

Whose $\left\{\begin{array}{l}\text{Latitude}\\ \text{Longitude}\end{array}\right\}$ is $\left\{\begin{array}{l}51 : 32 \text{ North.}\\ 00 : 00\end{array}\right.$

A TABLE *of the Sun's Declination for the Years*

Days.	Jan. S. °	′	Feb. S. °	′	March S. °	′	April N. °	′	May N. °	′	June N. °	′	Days.
1	22	59	16	58	07	24	04	43	15	12	22	07	1
2	22	53	16	41	07	01	05	06	15	30	22	15	2
3	22	48	16	23	06	38	05	29	15	48	22	23	3
4	22	41	16	05	06	15	05	52	16	05	22	30	4
5	22	35	15	46	05	52	06	14	16	22	22	36	5
6	22	27	15	28	05	29	06	37	16	39	22	43	6
7	22	20	15	09	05	05	06	59	16	56	22	49	7
8	22	12	14	50	04	42	07	22	17	12	22	54	8
9	22	03	14	31	04	19	07	44	17	28	22	59	9
10	21	54	14	11	03	55	08	06	17	44	23	04	10
11	21	45	13	52	03	32	08	28	17	59	23	08	11
12	21	35	13	32	03	08	08	50	18	14	23	12	12
13	21	24	13	11	02	44	09	12	18	29	23	15	13
14	21	14	12	51	02	21	09	34	18	44	23	19	14
15	[illegible]	03	12	30	01	57	09	55	18	58	23	21	15
16	20	51	12	10	01	33	10	16	19	12	23	23	16
17	20	39	11	49	01	10	10	37	19	25	23	25	17
18	20	[illegible]	11	27	00	46	10	58	19	39	23	27	18
19	20	14	11	06	00	22	11	19	19	52	23	28	19
20	20	[illegible]	10	45	N.	01	11	40	20	04	23	29	20
21	19	48	10	23	00	24	12	00	20	16	23	29	21
22	19	34	10	01	00	49	12	20	20	28	23	28	22
23	19	20	09	39	01	12	12	40	20	40	23	27	23
24	19	06	09	17	01	36	13	00	20	51	23	26	24
25	18	51	08	55	01	59	13	20	21	02	23	25	25
26	18	36	08	32	02	23	13	39	21	12	23	23	26
27	18	20	08	10	02	46	13	58	21	22	23	21	27
28	18	04	07	47	03	10	14	17	21	32	23	18	28
29	17	48			03	33	14	36	21	42	23	15	29
30	17	32			03	56	14	54	21	51	23	11	30
31	17	15			04	20			21	59			31

1761, 1765, 1769, 1773, 1777, 1781, 1785, 1789; *each being the first after Leap-Year.*

Days.	*July* N.		*August* N.		*Sept.* N *.		*Oct.* S.		*Nov.* S.		*Decem.* S.		Days.
	°	'	°	'	°	'	°	'	°	'	°	'	
1	23	07	17	58	08	10	03	20	14	36	21	55	1
2	23	03	17	43	07	49	03	44	14	55	22	04	2
3	22	58	17	27	07	27	04	07	15	13	22	12	3
4	22	53	17	11	07	04	04	30	15	32	22	20	4
5	22	48	16	55	06	42	04	53	15	50	22	28	5
6	22	42	16	39	06	20	05	16	16	08	22	35	6
7	22	35	16	22	05	57	05	39	16	26	22	42	7
8	22	28	16	05	05	34	06	02	16	44	22	48	8
9	22	21	15	48	05	12	06	25	17	01	22	54	9
10	22	14	15	30	04	49	06	48	17	18	22	59	10
11	22	06	15	12	04	26	07	11	17	34	23	04	11
12	21	58	14	54	04	03	07	34	17	51	23	09	12
13	21	49	14	36	03	40	07	56	18	07	23	13	13
14	21	40	14	17	03	17	08	18	18	23	23	16	14
15	21	31	13	59	02	54	08	41	18	38	23	20	15
16	21	21	13	40	02	31	09	03	18	53	23	22	16
17	21	11	13	21	02	07	09	25	19	08	23	24	17
18	21	00	13	01	01	44	09	47	19	22	23	26	18
19	20	50	12	42	01	21	10	09	19	36	23	27	19
20	20	38	12	22	00	57	10	30	19	50	23	28	20
21	20	27	12	02	00	34	10	52	20	03	23	29	21
22	20	15	11	42	09	11	11	13	20	16	23	28	22
23	20	03	11	21	S	13	11	34	20	28	23	27	23
24	19	50	11	01	00	36	11	55	20	41	23	26	24
25	19	37	10	40	01	00	12	16	20	52	23	25	25
26	19	24	10	19	01	23	12	36	21	04	23	23	26
27	19	10	09	58	01	47	12	57	21	15	23	20	27
28	18	57	09	37	02	10	13	17	21	25	23	17	28
29	18	43	09	15	02	34	13	37	21	36	23	14	29
30	18	28	08	54	02	57	13	57	21	45	23	10	30
31	18	13	08	32			14	17			23	05	31

A TABLE *of the Sun's Declination for the Year*

Days	Jan. S. °	Jan. S. '	Feb. S. °	Feb. S. '	March S. °	March S. '	April N. °	April N. '	May N. °	May N. '	June N. °	June N. '	Days
1	23	00	17	02	07	30	04	37	15	08	22	05	1
2	22	55	16	45	07	07	05	00	15	26	22	13	2
3	22	49	16	27	06	44	05	23	15	43	22	21	3
4	22	43	16	09	06	21	05	46	16	01	22	28	4
5	22	36	15	51	05	58	06	09	16	18	22	35	5
6	22	29	15	32	05	34	06	31	16	35	22	41	6
7	22	22	15	14	05	11	06	54	16	52	22	47	7
8	22	14	14	55	04	48	07	16	17	08	22	53	8
9	22	05	14	36	04	24	07	39	17	24	22	58	9
10	21	56	14	16	04	01	08	01	17	40	23	01	10
11	21	47	13	56	03	37	08	23	17	56	23	07	11
12	21	37	13	36	03	14	08	45	18	11	23	11	12
13	21	27	13	16	02	50	09	07	18	26	23	15	13
14	21	16	13	56	02	27	09	28	18	40	23	18	14
15	21	05	12	35	02	03	09	50	18	55	23	21	15
16	20	54	12	15	01	39	10	11	19	09	23	23	16
17	20	42	11	15	01	15	10	32	19	22	23	25	17
18	20	30	11	33	00	52	10	53	19	36	23	26	18
19	20	18	11	11	00	28	11	14	19	48	23	27	19
20	20	05	10	50	00	04	11	35	20	01	23	28	20
21	19	51	10	28	N	19	11	55	20	13	23	29	21
22	19	38	10	06	00	43	12	15	20	25	23	29	22
23	19	24	09	44	01	97	12	35	20	37	23	28	23
24	19	09	09	22	01	30	12	55	20	48	23	27	24
25	18	54	09	00	01	54	13	15	20	59	23	25	25
26	18	39	08	37	02	17	13	34	21	10	23	24	26
27	18	24	08	14	02	41	13	53	21	20	23	21	27
28	18	08	07	52	03	04	14	12	21	30	23	19	28
29	17	52			03	27	14	31	21	39	23	10	29
30	17	36			03	51	14	50	21	48	23	12	30
31	17	19			04	14			21	57			31

1762, 1766, 1770, 1774, 1778, 1782, 1786 1790 ;
each being the second after Leap-Year.

Days.	*July* N. °	′	*August* N. °	′	*Sept.* N. °	′	*Oct.* S. °	′	*Nov.* S. °	′	*Decem.* S. °	′	Days.
1	23	08	18	02	08	16	03	15	14	31	21	53	1
2	23	04	17	47	07	54	03	38	14	50	22	02	2
3	22	59	17	31	07	32	04	01	15	09	22	10	3
4	22	54	17	15	07	10	04	24	15	28	22	18	4
5	22	49	16	59	06	47	04	48	15	46	22	26	5
6	22	45	16	42	06	25	05	11	16	04	22	33	6
7	22	37	16	26	06	03	05	34	16	22	22	40	7
8	22	30	16	09	05	40	05	57	16	40	22	47	8
9	22	22	15	52	05	17	06	20	16	57	22	52	9
10	22	16	15	34	04	55	06	43	17	14	22	56	10
11	22	08	15	17	04	32	07	06	17	31	23	03	11
12	22	00	14	59	04	09	07	28	17	47	23	08	12
13	21	51	14	40	03	46	07	51	18	03	23	12	13
14	21	42	14	22	03	22	08	13	18	19	23	16	14
15	21	33	14	03	02	59	08	35	18	34	23	19	15
16	21	23	13	44	02	36	08	58	18	49	23	22	16
17	21	13	13	25	02	13	09	20	19	04	23	24	17
18	21	03	13	06	01	50	09	42	19	19	23	26	18
19	20	52	12	46	01	26	10	03	19	33	23	27	19
20	20	41	12	27	01	03	10	25	19	46	23	28	20
21	20	30	12	07	00	40	10	47	20	00	23	29	21
22	20	18	11	47	00	16	11	08	20	13	23	29	22
23	20	06	11	26	S	07	11	29	20	25	23	28	23
24	19	53	11	06	00	31	11	50	20	38	23	27	24
25	19	40	10	45	00	54	12	11	20	50	23	25	25
26	19	27	10	24	01	18	12	32	21	01	23	23	26
27	19	14	10	03	01	41	12	52	21	12	23	21	27
28	19	00	09	42	02	04	13	12	21	23	23	18	28
29	18	46	09	21	02	27	13	32	21	33	23	15	29
30	18	32	08	59	02	51	13	52	21	43	23	11	30
31	18	17	08	38			14	12			23	06	31

A TABLE of the Sun's Declination for the Years [illegible]

Days.	Jan. S. °	'	Feb. S. °	'	March S. °	'	April N. °	'	May N. °	'	June N. °	'	Days.
1	23	02	17	07	07	36	04	31	15	03	22	03	1
2	22	56	16	49	07	13	04	54	15	21	22	11	2
3	22	51	16	32	06	50	05	17	15	39	22	19	3
4	22	45	16	14	06	27	05	40	15	56	22	26	4
5	22	38	15	56	06	04	06	03	16	13	22	33	5
6	22	31	15	37	05	41	06	25	16	30	22	39	6
7	22	24	15	19	05	17	06	48	16	47	22	46	7
8	22	16	15	00	04	54	07	10	17	04	22	51	8
9	22	07	14	41	04	31	07	33	17	20	22	57	9
10	21	59	14	21	04	07	07	55	17	36	23	02	10
11	21	49	14	02	03	44	08	17	17	51	23	06	11
12	21	40	13	42	03	20	08	39	18	07	23	10	12
13	21	30	13	21	02	57	09	01	18	22	23	14	13
14	21	19	13	02	02	33	09	23	18	36	23	17	14
15	21	08	12	41	02	09	09	44	18	51	23	20	15
16	20	57	12	20	01	46	10	05	19	05	23	22	16
17	20	46	11	50	01	22	10	27	19	18	23	24	17
18	20	33	11	38	00	58	10	48	19	32	23	26	18
19	20	21	11	17	00	35	11	08	19	45	23	27	19
20	20	08	10	56	00	11	11	29	19	58	23	28	20
21	19	55	10	34	N	12	11	50	20	10	23	29	21
22	19	42	10	12	00	36	12	10	20	22	23	29	22
23	19	27	09	50	01	00	12	30	20	34	23	28	23
24	19	13	09	28	01	24	12	50	20	45	23	27	24
25	18	59	09	06	01	47	13	10	20	56	23	26	25
26	18	42	08	44	02	11	13	29	21	07	23	24	26
27	18	28	08	21	02	34	13	48	21	17	23	22	27
28	18	12	07	59	02	58	14	07	21	27	23	19	28
29	17	56			03	21	14	26	21	37	23	17	29
30	17	40			03	44	14	44	21	46	23	13	30
31	17	23			04	08			21	55			31

1763, 1767, 1771, 1775, 1779, 1783, 1787, 1791; *each being the third Year after Leap-Year.*

Days.	July N.		August N.		Sept. N.*		Oct. S.		Nov. S.		Decem. S.		Days.
	°	′	°	′	°	′	°	′	°	′	°	′	
1	23	09	18	06	08	22	03	08	14	26	21	50	1
2	23	05	17	51	08	00	03	32	14	45	21	59	2
3	23	01	17	35	07	38	03	55	15	04	22	08	3
4	22	56	17	20	07	16	04	18	15	23	22	16	4
5	22	50	17	04	06	54	04	41	15	41	22	24	5
6	22	45	16	47	06	31	05	05	15	59	22	31	6
7	22	39	16	31	06	09	05	28	16	17	22	38	7
8	22	32	16	14	05	46	05	51	16	35	22	45	8
9	22	25	15	56	05	24	06	14	16	52	22	51	9
10	22	18	15	39	05	01	06	36	17	09	22	57	10
11	22	10	15	21	04	38	06	59	17	26	23	02	11
12	22	02	15	03	04	15	07	21	17	42	23	07	12
13	21	54	14	45	03	52	07	44	17	59	23	12	13
14	21	45	14	27	03	29	08	07	18	14	23	15	14
15	21	36	14	08	03	06	08	29	18	30	23	18	15
16	21	26	13	50	02	43	08	52	18	45	23	21	16
17	21	16	13	30	02	19	09	14	19	00	23	23	17
18	21	06	13	11	01	56	09	36	19	15	23	25	18
19	20	55	12	52	01	36	09	57	19	29	23	27	19
20	20	44	12	32	01	09	10	19	19	43	23	28	20
21	20	33	12	12	00	46	10	41	19	56	23	29	21
22	20	21	11	52	00	23	11	02	20	09	23	29	22
23	20	09	11	32	S.	01	11	23	20	22	23	28	23
24	19	57	11	11	00	24	11	44	20	34	23	27	24
25	19	44	10	51	00	48	12	05	20	46	23	26	25
26	19	31	10	30	01	11	12	26	20	58	23	24	26
27	19	18	10	09	01	35	12	46	21	09	23	21	27
28	19	04	09	48	01	58	13	07	21	19	23	19	28
29	18	50	09	26	02	21	13	27	21	30	23	15	29
30	18	36	09	05	02	45	13	47	21	40	23	12	30
31	18	21	08	34			14	06			23	08	31

A TABLE of the Sun's Declination for the Years

Days.	Jan. S.		Feb. S.		March S.		April N.		May N.		June N.		Days.
	°	'	°	'	°	'	°	'	°	'	°	'	
1	23	03	17	11	07	19	04	48	15	17	22	09	1
2	22	58	16	53	06	56	05	11	15	34	22	17	2
3	22	52	16	36	06	33	05	34	15	52	22	24	3
4	22	46	16	18	06	10	05	57	16	09	22	31	4
5	22	40	16	00	05	46	06	20	16	26	22	38	5
6	22	33	15	42	05	23	06	42	16	43	22	44	6
7	22	25	15	23	05	00	07	05	17	00	22	50	7
8	22	18	15	05	04	36	07	27	17	16	22	55	8
9	22	10	14	45	04	13	07	50	17	32	23	00	9
10	22	01	14	26	03	49	08	12	17	48	23	05	10
11	21	52	14	07	03	26	08	34	18	03	23	09	11
12	21	42	13	47	03	02	08	56	18	18	23	13	12
13	21	32	13	27	02	39	09	17	18	33	23	16	13
14	21	22	13	06	02	15	09	39	18	47	23	19	14
15	21	11	12	46	01	51	10	00	19	01	23	22	15
16	20	50	12	25	01	28	10	22	19	15	23	24	16
17	20	48	12	05	01	04	10	43	19	29	23	26	17
18	20	36	11	43	00	40	11	03	19	42	23	27	18
19	20	24	11	22	00	17	11	24	19	55	23	28	19
20	20	11	11	01	N	07	11	45	20	07	23	29	20
21	19	58	10	39	00	31	12	05	20	19	23	29	21
22	19	45	10	18	00	54	12	25	20	31	23	28	22
23	19	31	09	56	01	18	12	45	20	43	23	27	23
24	19	17	09	34	01	42	13	05	20	54	23	26	24
25	19	02	09	11	02	05	13	24	21	04	23	24	25
26	18	47	08	49	02	29	13	44	21	15	23	22	26
27	18	32	08	27	02	52	14	03	21	25	23	20	27
28	18	16	08	04	03	15	14	21	21	35	23	17	28
29	18	00	07	41	03	39	14	40	21	44	23	14	29
30	17	44			04	02	14	58	21	53	23	10	30
31	17	28			04	25			22	01			31

1764, 1768, 1772, 1776, 1780, 1784, 1788, 1792; *each being Leap-year.*													
Days.	*July* N.		*August* N.		*Sept.* N *.		*Oct.* S.		*Nov.* S.		*Decem.* S.		Days.
	°	′	°	′	°	′	°	′	°	′	°	′	
1	23	06	17	55	08	05	03	26	14	40	21	57	1
2	23	02	17	39	07	43	03	49	14	59	22	06	2
3	22	57	17	23	07	21	04	13	15	18	22	14	3
4	22	52	17	07	06	59	04	36	15	37	22	22	4
5	22	46	16	51	06	37	04	59	15	55	22	30	5
6	22	40	16	35	06	14	05	22	16	13	22	37	6
7	22	34	16	18	05	52	05	45	16	30	22	43	7
8	22	27	16	00	05	29	06	08	16	48	22	50	8
9	22	20	15	43	05	06	06	31	17	05	22	55	9
10	22	12	15	26	04	43	06	54	17	26	23	01	10
11	22	04	15	08	04	21	07	16	17	39	23	05	11
12	21	56	14	50	03	58	07	39	17	55	23	10	12
13	21	47	14	31	03	35	08	01	18	11	23	14	13
14	21	38	14	13	03	11	08	24	18	26	23	17	14
15	21	28	13	54	02	48	08	46	18	41	23	20	15
16	21	19	13	35	02	25	09	08	18	57	23	23	16
17	21	08	13	16	02	02	09	30	19	11	23	25	17
18	20	58	12	56	01	38	09	52	19	25	23	26	18
19	20	47	12	37	01	15	10	14	19	39	23	28	19
20	20	36	12	17	00	52	10	36	19	53	23	29	20
21	20	24	11	57	00	28	10	57	20	06	23	29	21
22	20	12	11	37	00	05	11	18	20	19	23	28	22
23	20	00	11	16	S	19	11	39	20	31	23	27	23
24	19	47	10	56	00	42	12	00	20	43	23	26	24
25	19	34	10	35	01	05	12	21	20	55	23	24	25
26	19	21	10	14	01	29	12	41	21	06	23	22	26
27	19	07	09	53	01	52	13	02	21	18	23	19	27
28	18	53	09	32	02	16	13	25	21	28	23	16	28
29	18	39	09	10	02	39	13	42	21	38	23	13	29
30	18	25	08	49	03	02	14	02	21	48	23	09	30
31	18	10	08	27			14	21			23	04	31

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A Defcription of the TABLES of the Sun's Declination.

THESE tables are in general for four years: leap-year, firft, fecond, and third year after leap-year; and confequently any year.

Each year (taking up two pages) hath the firft fix months of the year on the left-hand page, and the laft fix months are on the right-hand page; the names of the months are at the head of each column, and the days of each month in the right and left-hand columns of each page.

The firft table fheweth the fun's declination every day for the firft years after leap-year, being 1761, 1765, 1769, 1773, 1777, &c. and takes up Pages (426) and (427). The fecond table is for 1762, 1766, 1770, 1774, 1778, &c. being fecond years after leap-year, in pages (428) and (429). The next table in pages (430) and (431) is for the third years after leap-year: the fourth table in pages (432) and (433) fheweth the fun's declination for leap-years, being 1764, 1768, 1772, 1776, 1780, &c.

Under the name of the month, is the name of the declination either north or fouth: only the column for March and September, hath two Names; that is, under March is S. and againft the 21ft or 20th day (according as it is leap-year, or 1ft, 2d, 3d year after) is N. for North; and under September is N. and againft the 23d or 24th Day is S. for fouth; intimating the declination is fouth in March, 'till the 21ft or 20th day, and all the remaining part of the month it is N. or north: in like manner in September, it is north 'till the 23d or 24th day, and from thence to the month's End it is S. or fouth.

A TABLE

A TABLE of Angles, which every Rumb (or Point of *the Compass*) maketh with the *Meridian*.

North	*South*	*Point*	*D.*	*M.*	*North*	*South*
		1/4	2	49		
		1/2	5	37		
		3/4	8	26		
N by E	S by E	1	11	15	N by W	S by W
		1 1/4	14	24		
		1 1/2	16	52		
		1 3/4	19	41		
N N E	S S E	2	22	30	N N W	S S W
		2 1/4	25	19		
		2 1/2	28	7		
		2 3/4	30	56		
NE by N	SE by S	3	33	45	NW by N	SW by S
		3 1/4	36	34		
		3 1/2	39	22		
		3 3/4	42	11		
No. East	Sou. East	4	45	00	No. West	Sou. West
		4 1/4	47	49		
		4 1/2	50	37		
		4 3/4	53	26		
NE by E	SE by E	5	56	15	NW by W	SW by W
		5 1/4	59	4		
		5 1/2	61	52		
		5 3/4	64	41		
E N E	E S E	6	67	30	W N W	W S W
		6 1/4	70	19		
		6 1/2	73	7		
		6 3/4	75	56		
E by N	E by S	7	78	45	W by N	W by S
		7 1/4	81	34		
		7 1/2	84	22		
		7 3/4	87	11		
East	East	8	90	00	West	West

F I N I S.

A TABLE of Angles, which every Rumb (or Point of the Compass) maketh with the Meridian.

North	South	Points	D. M.	North	South
		1/4	2 49		
		1/2	5 37		
		3/4	8 26		
N by E	S by E	1	11 15	N by W	S by W
		1 1/4	14 4		
		1 1/2	16 52		
		1 3/4	19 41		
N N E	S S E	2	22 30	N N W	S S W
		2 1/4	25 19		
		2 1/2	28 7		
		2 3/4	30 56		
NE by N	SE by S	3	33 45	NW by N	SW by S
		3 1/4	36 34		
		3 1/2	39 22		
		3 3/4	42 11		
No. East	Sou. East	4	45 00	No. West	Sou. West
		4 1/4	47 49		
		4 1/2	50 37		
		4 3/4	53 26		
NE by E	SE by E	5	56 15	NW by W	SW by W
		5 1/4	59 4		
		5 1/2	61 52		
		5 3/4	64 41		
E N E	E S E	6	67 30	W N W	W S W
		6 1/4	70 19		
		6 1/2	73 7		
		6 3/4	75 56		
E by N	E by S	7	78 45	W by N	W by S
		7 1/4	81 34		
		7 1/2	84 22		
		7 3/4	87 11		
East	East	8	90 00	West	West